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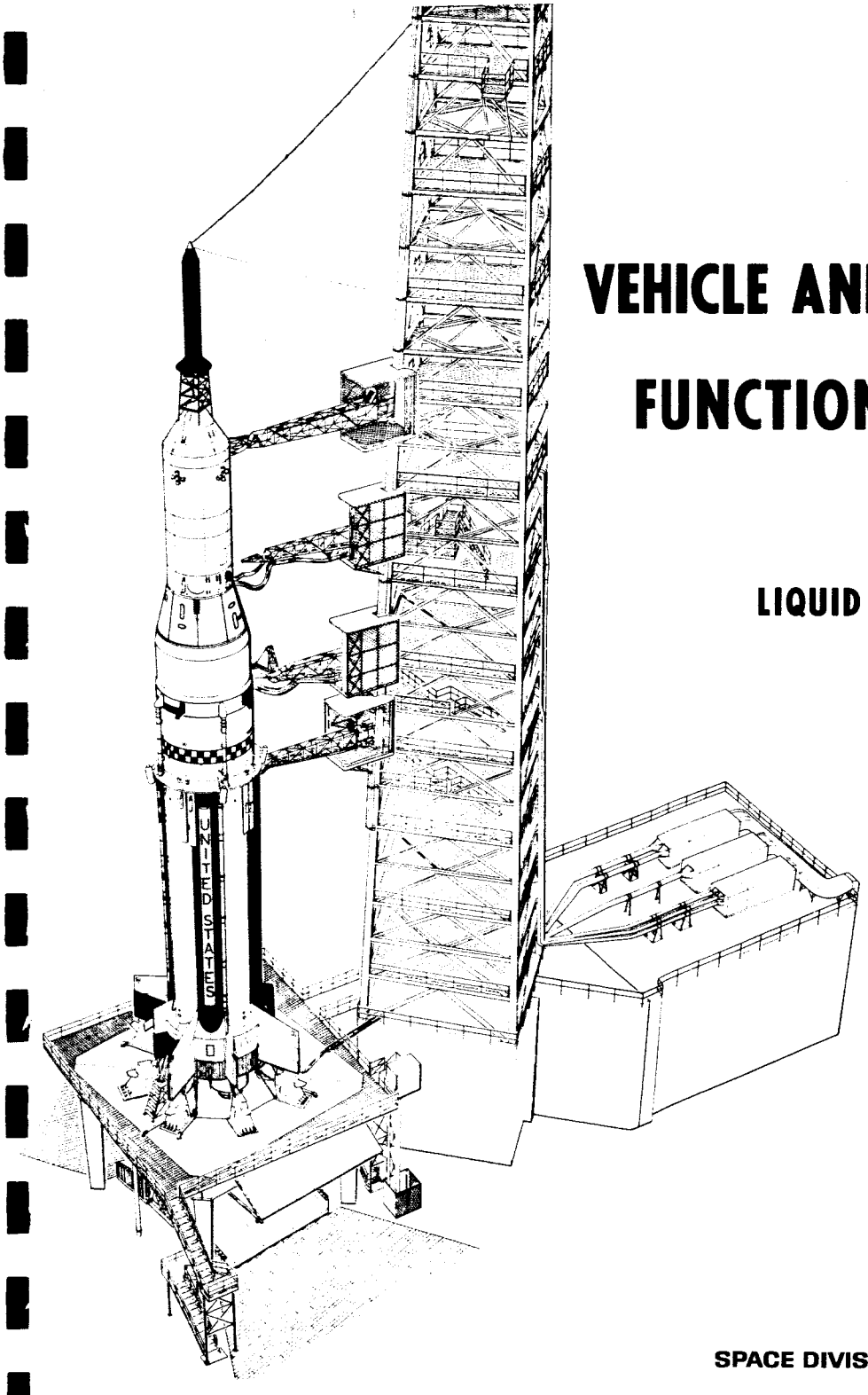
VOLUME III



SA-7

VEHICLE AND LAUNCH COMPLEX FUNCTIONAL DESCRIPTION

LIQUID HYDROGEN SYSTEM

SPACE DIVISION CHRYSLER CORPORATION

HUNTSVILLE OPERATIONS

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FOREWORD

This volume has been prepared for the Functional Integration Section, Systems Integration and Operations Branch, Vehicle Systems Division, Propulsion and Vehicle Engineering Laboratory, by the Engineering Communications Department, Chrysler Corporation Space Division, under contract number NAS8-4016.

The following series, of which this volume is a part, functionally describes the mechanical and electromechanical systems of Saturn I SA-7 space vehicle and Launch Complex 37:

Volume I.	RP-1 Fuel System
Volume II.	LOX System
Volume III.	LH_2 System
Volume IV.	Nitrogen and Helium Storage Facility
Volume V.	Pneumatic Distribution System
Volume VI.	Environmental Control System
Volume VII.	Launch Pad Accessories
Volume VIII.	H-1 Engine and Hydraulic System
Volume IX.	RL10A-3 Engine and Hydraulic System
Volume X.	Separation and Flight Termination Systems
Volume XI.	Supplement: Legend and Composite Schematic

Each volume contains mechanical schematics and a list of applicable finding numbers.

Volume III describes those components that are active during countdown, launch, and flight: it specifically excludes maintenance and checkout procedures. Only information available by January 10, 1964, has been included.

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MAY 1964

ENGINEERING COMMUNICATIONS DEPARTMENT

SPACE DIVISION CHRYSLER CORPORATION

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58404/ZB013/250

1. LH_2 SYSTEM DESCRIPTION

The Saturn I vehicle and associated launch complex contains a liquid hydrogen (LH_2) fuel system to supply the vehicle S-IV (second stage) propulsion system. The ground based portion of the fuel system consists primarily of a storage tank, transfer line, and associated control and monitoring systems. Filling, venting, and pressurization connections to the S-IV stage are made through two swing arms on the umbilical tower. Actuation of the swing arms to effect retraction from the vehicle is described in Volume VII.

The S-IV stage contains a propellant container, which is divided into LOX and LH_2 sections. Six suction lines below the fuel container supply LH_2 to the RL10A-3 engine system during flight. Two separate networks of lines and associated equipment connected to the top of the container provide venting and pressurization during ground operations and during flight.

2. LH_2 STORAGE FACILITY DESCRIPTION

The major components in the LH_2 storage facility consist of an LH_2 storage tank, a liquid level monitoring system, a storage tank evacuation system, a storage tank fill system, a storage tank pressurization system, an LH_2 transfer line, a launch area vent system, GN_2 and helium purge system, launch and storage facility burn ponds, a pneumatic control panel, LH_2 main fill and topping control, and remote monitoring and control equipment located in the Launch Control Center (LCC), the Automatic Ground Control Station (AGCS), and the Electrical Equipment House (EEH). Equipment in these systems initiates, controls, connects, monitors, terminates, and otherwise facilitates LH_2 storage and transfer to or from the S-IV stage fuel container. A description of the more complex components and subsystems follows. Remaining individual items are described in the parts list, in the LH2 system schematics, and in the system operations section of this document.

Figure 2, page 55, representing the LH_2 storage facility, and figure 3, page 57, representing the launch facility transfer system and the S-IV stage fuel system, should be used in conjunction with the text to follow the various flow routes of the LH_2 system operation.

2.1. Pneumatic Valves

The following pneumatically operated valves control the flow passage by hydrogen in various LH_2 storage facility lines:

a. LH_2 Storage Tank Fill Valve A3302.

b. LH_2 Storage Tank Main Vent Valve A3304.

c. LH_2 Transfer Line Fill Valve A3306.

d. LH_2 Transfer Line Cooldown Valve A3307.

e. LH_2 Transfer Line Vent Valve A3308.

Each valve (normally closed) requires 750-psig GN_2 pressure to open and automatically closes on 750-psig GN_2 pressure failure. Valve operation is effected by a high pressure cylinder actuator, which receives 750-psig GN_2 from the pneumatic control panel. Admission of GN_2 is controlled by two 3-port solenoid valves, which are energized by command signals from the LCC and EEH control and monitor panels. The normally closed solenoid valve opens and directs pressure to the valve opening actuator, while pressure on the closing side of the actuator is vented through the normally open solenoid valve. When the command signals are removed from the solenoids, the reverse occurs, and a spring aids in closing the valve. Valve position is monitored by indicator lights on the EEH LH_2 monitor panel and the LCC LH_2 components panel.

2.2. LH_2 Main Fill and Topping Control

The main fill and topping control unit, mounted on the umbilical tower at the 108-foot level, provides the following functions:

a. S-IV fuel container filling at 2000 gpm (max.) to a 95% LH_2 level.

b. Container replenishing at 450 gpm (max.) to a 99.25% LH_2 level.

c. Reduced flow container replenishing at 20 gpm at 99.25% LH_2 level (replenish rate at 20 gpm is inadequate to compensate for container boiloff losses).

d. Cycling between 450 gpm at 99% LH_2 level and 20 gpm at 99.25% LH_2 level to maintain container load between the two levels.

e. Final replenish at 450 gpm to fill fuel container to 100% LH_2 level.

f. Venting of main fill and topping control after the S-IV fuel container is filled.

g. Supply of LH_2 to the Helium Pre-Cool Heat Exchanger A3950 during LH_2 tanking operations.

2.2.1. LH_2 Flow Control Components. The following pneumatically operated valves, in the main fill and topping control unit, control LH_2 flow to various areas:

a. Main Fill Valve A3911.

b. Replenish Valve A3910.

c. Vent Valve A3912.

d. Helium Pre-Cool Heat Exchanger LH_2 Inlet Valve A3917.

2.2.2. Valve Control. A 4-port solenoid valve provides valve control. The solenoid valve directs 750-psig GN_2 from valve panel B to the appropriate side of the valve actuator piston and, at the same time, vents the opposite side of the piston to atmosphere. Replenish Valve A3910, unlike the other three valves in the control unit, is provided with two 4-port solenoid valves that provide full replenish and reduce replenish control.

2.3. LH_2 Control Center

The LH_2 system equipment in the Launch Control Center consists of panels and control equipment necessary for initiating, monitoring, and controlling LH_2 transfer operations. These functions are performed with the aid of equipment located in propellant loading racks No. 6 and No. 7 that distributes electrical power and controls (through timers) the automatic sequence.

2.3.1. LH_2 Control Panel. The LH_2 control panel is used to initiate the commands and to provide visual monitoring of sequences for the operation or simulation of LH_2 transfer and draining operations.

The 'power on-off' switch controls electric power to other LH_2 control panel components.

The 'function selector' switch has four positions: 'off,' 'operate,' 'simulate,' and 'manual.' The 'operate' position provides automatic operation, requiring only the momentary depression of the sequence pushbuttons to initiate the three sequences of operation. The 'simulate' position performs the simulated fill operation prior to countdown. Simulate is the same as operate except LH_2 does not flow during simulated operation. The 'manual' position allows manual operation of components during checkout operations.

The 'control return' switch is used to return control of transfer operations to the S-IV stage contractor (Douglas Aircraft Co.) equipment when required.

Prerequisite indicator lights are mounted across the top of the panel. As each prerequisite is completed, its corresponding indicator will be illuminated. When all the prerequisites are met, the 'standby' indicator in the fill sequence group of indicators will illuminate, indicating that the S-IV stage fuel container is ready for filling.

'Fill,' 'secure,' and 'drain' pushbutton switches initiate each of these sequences as required. The fill sequence is initiated only when the fill

sequence standby indicator light and the prerequisite indicator lights are illuminated. Progress of the sequence is then monitored on indicator lights to the right of the fill pushbutton. The secure and drain sequences are initiated and monitored in the same manner.

2.3.2. LH_2 Monitor Panel. The LH_2 monitor panel provides a means of remotely monitoring various equipment in the storage facility, launch area, and vehicle. The ten indicators mounted on the panel perform the following functions:

a. The filter differential pressure indicator displays the pressure difference across transfer line Filter A3905.

b. The transfer line pressure indicator displays the LH_2 pressure in the transfer line.

c. The transfer line outlet temperature indicator displays the temperature of LH_2 leaving the storage area.

d. The vehicle vent pressure indicator displays vehicle vent stack pressure.

e. The subcooler level indicator displays LH_2 level in the shell side of Subcooler A3752.

f. The subcooler inlet line temperature indicator displays the shell side pressure of Subcooler A3752 being maintained by Vacuum Pump A3751.

g. The subcooler inlet line temperature indicator displays LH_2 temperature entering the tube side of Subcooler A3752.

h. The storage tank level indicator displays the LH_2 level in Storage Tank A3753.

i. The storage tank pressure indicator displays storage tank ullage pressure.

j. The vehicle container pressure indicator displays S-IV LH_2 container pressure.

2.3.3. LH_2 Components Panel. The LH_2 components panel provides manual control and visual monitoring of remotely located LH_2 facility components. Manual control of components is possible when the function selector switch on the LH_2 control panel is in the 'manual' position. Indicator lights on the panel show the condition or position of the various components.

3. LH_2 STORAGE FACILITY OPERATION

Storage operations include the storage facility purge, storage tank annular space evacuation, storage tank fill, and pre-operational pneumatic and electrical systems checkout.

3.1. Storage Facility Purge (figure 2)

A storage facility purge sequence is undertaken before countdown when air has been permitted to enter the storage tank. This sequence prevents the formation of an explosive mixture of air and hydrogen when LH_2 is admitted to the storage tank and associated lines. The sequence consists of a GN_2 purge followed by a warm GH_2 purge. The GH_2 may be obtained from the same LH_2 service trailers that are used later to fill the tank. A heater, which is large enough to convert approximately 30 gpm of LH_2 to warm GH_2, is fitted with couplings to connect the service trailer to the LH_2 fill manifold. To prevent liquefaction and freezing of the GN_2 or other impurities, only warm GH_2 is admitted to the tank. A GN_2 source is attached to storage facility couplings. Beginning with all valves closed, the LH_2 storage tank and associated lines are purged.

3.1.1. Storage Facility Purge Operation. Launch and storage facility burn pond pilots must be on. Vacuum Pump A3750 and Motor A3938 are started, Manual Shut-Off Valve A3323 is opened, and Storage Tank A3753 annular space is evacuated to 1 psia. The gases are vented to the storage facility burn pond. Shut-Off Valve A3323 is then closed and Vacuum Pump A3750 is stopped. Manual Shut-Off Valve A3334 may be opened during this and other evacuation sequences to relieve vacuum pressure in the vent piping.

A dry, filtered (40 micron maximum) GN_2 source is attached to Coupling Half A3936. Manual Valves A3340, A3322, and A3320 are opened. Solenoid Valves A3397 and A3398 open Tank Fill Valve A3302 when the 'fill valve' switch on the EEH LH_2 monitor panel is depressed. The GN_2 flows to the storage tank through Coupling Half A3936, Shut-Off Valve A3340, Orifice A3605, Manual Valve A3322, Tank Fill Valve A3302, and Manual Valve A3320. The GN_2 flowrate through Orifice A3605 is approximately 5 scfm. Tank Fill Valve A3302 is manually closed when tank pressure increases to 3 psig.

The LH_2 liquid level lines are purged and dried by opening Shut-Off Valves A3352 through A3354 and A3356 through A3364, allowing GN_2 from the storage tank to flow through the valves to atmosphere through Shut-Off Valve A3356. The purge is continued for several minutes. All the liquid level shut-off valves are then closed. The purge and evacuation sequence is continued until oxygen concentration in the storage tank is less than 1.5%. A gas sample may be removed from the pressurized tank by opening Manual Shut-Off Valves A3359, A3361, and A3353 and Vent Valve A3356 or by opening Manual Shut-Off Valves A3360 and A3362 and Vent Valve A3356. Oxygen Analyzer A3620 can be connected to the fitting downstream from Vent Valve A3356 to examine the sample.

When the oxygen concentration drops below 1.5%, a dewpoint measurement is taken of the gas sample. If the dewpoint of the sample is -20°F or less, then additional samples are taken at half-hour intervals for about two hours or until the dewpoint stabilizes below -20°F. If after four hours the dewpoint is above -20°F or if it was above -20°F at the initial reading, the storage tank must be re-evacuated and recharged with GN2. If the dewpoint remains below -20°F the purging operations continue. With a positive pressure in the storage tank, vaporizer inlet Manual Shut-Off Valve A3301 is opened. Pneumatic Tank Pressurization Regulator A3305 is then opened by Solenoid Valve A3387 and Pneumatic Controller A3544. After purging the line between the storage tank and the regulator for a few minutes, the regulator is closed. The transfer line is purged between the storage tank and the subcooler (described in paragraph 3.1.2) by opening Manual Supply Valve A3303 and by depressing the LCC LH_2 components panel 'transfer line fill' switch. Solenoid Valves A3391 and A3392 open Pneumatic Transfer Line Fill Valve A3306. GN_2 enters the transfer line and passes through Supply Valve A3303 and Fill Valve A3306. The LCC LH_2 components panel 'transfer line cooldown' switch is then depressed to signal Solenoid Valves A3389 and A3390 to open Pneumatic Cooldown Valve A3307. GN_2 is then evacuated from the storage tank.

The purge gas heater is attached to one of Coupling Halves A3940, A3941, A3942, or A3943 below Manual Fill Valves A3330, A3331, A3332, and A3333. A flexible transfer line hose connects the heater and the LH_2 trailer. Shut-Off Valves A3340 and A3322 are opened. The manual fill valve to which the LH_2 trailer and heater are connected is also opened. GN_2 enters the fill manifold and fill line. After a short period of time, Shut-Off Valves A3340 and A3322 are closed. Manual Shut-Off Valve A3335 and the LH_2 hand valve on the service trailer are opened. LH_2 from the trailer flows into the heater where it is converted to GH_2. The GH_2 enters the fill manifold and fill line, which contained GN_2. Shut-Off Valve A3322 is opened for five minutes to vent GH_2 and GN_2 through Drain Valve A3335 to the storage facility burn pond. The fill manifold and fill line are also vented for 10 seconds through Manual Vent Valve A3341. Fill Valve A3302 is opened and the storage tank is filled to a positive pressure with GH_2. The storage tank is evacuated and re-filled until analysis reveals that gas impurity concentration in the tank is less than 100 parts per million. Once again the LH_2 tank is pressurized with GH_2; then all facility valves are closed and the heater is disconnected from the fill manifold.

3.1.2. GN_2 Purge Combinations. Various combinations of GN_2 purge networks may be utilized, when necessary, to purge sections of the storage facility.

Coupling Half A3937, Manual Shut-Off Valves A3337 and A3336, Orifice A3606, and Check Valve A3348 provide a purging network for the LH_2 transfer line between Subcooler A3652 and LH_2 Storage Tank A3753. Manual Drain Valve A3343 provides venting of the purge network to the storage facility vent system. Coupling Half A3937, Manual Shut-Off Valve A3327, and Orifices A3601 and A3602 provide a purging network for the main storage tank vent line and the steady-state vent line. Flow through Orifices A3601 and A3602 is 20.0

and 1.0 scfm, respectively. Orifice A3607 restricts GN_2 flow to storage tank Vacuum Pump Motor A3938 to 0.5 scfm. Orifice A3610 restricts GN_2 flow to Subcooler Liquid Level Probe A3509 to 0.1 scfm. Orifices A3608 and A3609 restrict the flow of GN_2 to the housing of Subcooler Vacuum Pump A3751 and Motor A3939 to 0.5 scfm. Admission of GN_2 to the pump housing is controlled by Manual Shut-Off Valve A3401. GN_2 at 50 psig is made available at Coupling Halves A3947 and A3948 (figure 3) at the launch area for purging the main vent and auxiliary vent lines, when required. The GN_2 passes through Orifices A3603 and A3604 and Manual Shut-Off Valves A3329 and A3328. Respective flowrates are 20.0 and 8.0 scfm.

3.2. Storage Tank Fill (figure 2)

A storage tank filling sequence is undertaken after the tank and associated equipment and lines are properly purged and relieved of impurities. One or more LH_2 service trailers supply LH_2 to the Storage tank until the proper level is attained.

3.2.1. Preparation. Pneumatic Steady-State Pressure Controller A3551 is set to retain 4 psig in the tank, allowing the hydrogen to remain in contact with the warm tank walls for an extended time before venting takes place. Manual Shut-off Valves A3369, A3370, and A3415 are opened to admit tank pressure to the controller.

The flexible hoses from the LH_2 trailers are connected to Coupling Halves A3940, A3941, A3942, or A3943. Manual Fill Valves A3330, A3331, A3332, or A3333, and Shut-off Valves A3322 and A3340 are opened.

The fill manifold is purged for two minutes with GN_2, which passes through Coupling Half A3936, Shut-Off Valve A3340, Orifice A3605, Shut-Off Valve A3322, the fill manifold, the manifold fill valves and coupling halves and escapes to the atmosphere through the LH_2 trailer bleed valves. Shut-Off Valves A3322 and A3340 and the LH_2 trailer bleed valves are then closed.

Drain Valve A3335 is then opened to vent the fill manifold and associated lines to the storage facility burn pond.

LH_2 Fill Valve A3320 and the LH_2 valve on the service trailer are opened. LH_2 flows from the trailer through the coupling halves, and manual valves into the relatively warm fill manifold. The LH_2 vaporizes and Shut-Off Valve A3322 is opened for about 10 seconds to vent the GH_2 to the burn pond. After 10 seconds, the fill lines and manifold should be cooled sufficiently to begin filling the storage tank.

3.2.2. Operation. The fill valve switch on the EEH LH_2 monitor panel is depressed to open Tank Fill Valve A3302. LH_2, which is already present in the upstream section of the fill line and in the fill manifold, passes through Tank Fill Valve A3302 and Manual Valve A3320 into the Storage Tank A3753.

During filling operations, LH_2 supply pressure in the service trailer is maintained between 12 and 15 psig as long as possible. When supply pressure drops below 5 psig, the LH_2 trailer is replaced and filling continues until the storage tank reaches the required level (approximately 125,000 gallons).

Relief Valves A3644 and A3647 provide over pressure protection for the fill manifold and fill line by venting excess pressure at 100 psig to the storage facility burn pond.

Shut-Off Valves A3352, A3353, A3357, A3358, A3359, A3360, A3361, A3362, A3363, and A3364 are opened in the combinations required during any storage tank operation to admit tank pressure to Liquid Level Gage A3504 for local monitoring and to Differential Pressure Transducer A3502 for remote monitoring. The differential pressure transducer provides signals to the EEH and LCC LH_2 monitor panel level indicators, which indicate LH_2 tank liquid quantity from 0 to 125,000 gallons. Differential Limiter A3414 protects Differential Pressure Transducer A3502 from pressure surges during facility operations. Local tank pressure is monitored by Pressure Gage A3532 during storage operations. Pressure Transducer A3533 provides remote monitoring of tank pressure by providing signals to indicators on the EEH and LCC LH_2 monitor panels.

As the LH_2 level rises, Pneumatic Steady-State Vent Regulator A3338 opens to relieve tank pressure in excess of 4 psig. Vented pressure is exhausted to atmosphere through Check Valve A3382. Steady-State Controller A3551 senses LH_2 Storage Tank A3743 ullage pressure and controls the position of Steady-State Vent Regulator A3338 by regulating the pressure differential across the regulator actuator. The controller is protected from overpressure by Snubber A3552.

When the storage tank has been filled to 125,000 gallons, the fill operation is terminated by closing Fill Valve A3302, Supply Valve A3320, and the LH_2 valve on the supply trailer. The fill line may be 'inerted' by opening Shut-Off Valves A3322 and A3340 and Fill Manifold Vent Valve A3341, thereby allowing GN_2 to flow through the fill manifold to atmosphere; or the fill manifold can be vented to the storage facility burn pond by closing Shut-Off Valve A3340 and Vent Valve A3341 and opening Manual Shut-Off Valve A3335.

The fill line is maintained at a positive pressure to prevent contaminants from entering the line. Shut-Off Valves A3340 and A3322 are opened to allow GN_2 to flow into the line; then the valves are closed. If LH_2 is to be stored for a period of time before launch, Steady-State Controller A3551 is set to open Steady-State Vent Regulator A3338, which vents the storage tank if ullage pressure increases above 0.5 psig.

3.3. Storage Tank Annular Space Evacuation (figure 2)

After the annular space has been filled with perlite, the remaining air is evacuated from the annular space to ensure maximum insulating efficiency and thus prevent rapid boil-off of the LH_2.

3.3.1. Preparation. The following preparations must be completed before the annular space can be evacuated:

a. Manual Shut-Off Valve A3323 is closed to prevent unnecessary evacuation of the storage tank.

b. Manual Shut-Off Valves A3325 and A3326 may be opened to admit tank vacuum to Vacuum Transducer A3622.

c. Manual Vent Valve A3368 is closed to seal off the storage tank annular space from the atmosphere.

d. Manual Shut-Off Valves A3324 and A3380 are opened.

3.3.2. Operation. The annular space evacuation operation is initiated by starting Vacuum Pump A3750 and Motor A3938. Air evacuated from the annular space through Shut-Off Valves A3380 and A3324 and Vacuum Pump A3750 is exhausted to the storage facility burn pond. (A portable vacuum pump may be connected to the fitting below Vent Valve A3368 to provide annular space evacuation whenever Vacuum Pump A3750 or Motor A3938 is rendered inoperative by malfunction or repair.)

The annular space is evacuated to about 10 microns Hg as sensed by Vacuum Transducer A3622 and displayed on a vacuum indicator. After the annular space has been properly evacuated, Shut-Off Valves A3380 and A3324 are closed and Vacuum Pump A3750 is shut down.

Burst Disc A3632 provides overpressure protection for the annular space, by relieving at 5 psig in the event of LH_2 leakage into the annular space.

3.4. LH_2 Storage Tank Pressurization System (figure 2)

The storage tank pressurization system maintains storage tank ullage pressure at about 0.5 psig during steady-state conditions (LH_2 fill and storage) and about 42 psig during S-IV stage filling operations. During tank fill or steady-state conditions, excess pressure is vented to atmosphere through a three-inch line in the top of the storage tank. Preflight tank pressurization is accomplished by drawing off part of the LH_2, vaporizing it, and returning the GH_2 to the ullage area of the storage tank through an eight-inch line. Excess pressure is vented to the storage facility burn pond through an eight-inch line.

3.4.1. Steady-State Vent Control Regulator. Pneumatically operated Steady-State Vent Regulator A3338 maintains storage tank pressure at 0.5 psig during LH_2 storage and during storage tank fill by controlling the venting of GH_2 boiling off from the stored LH_2. The regulator, which is normally closed, is positioned by a piston actuator that receives 25-psig GN_2 from the LH_2 pneumatic control panel. Differential pressure across the actuator piston is regulated by Pneumatic Controller A3551, which supplies an increasing signal pressure of 3 to 15 psig to open the regulator as ullage pressure rises above

a set point. The controller and steady-state vent regulator continue to cycle until tank venting stabilizes at a point where tank pressure remains constant. Venting of excess tank pressure is effected by Storage Tank Vent Valve A3304 when its controlling Solenoid Valves A3395 and A3396 are actuated by Pressure Switch A3539 if tank pressure increases to 60 psig.

3.4.2. Tank Pressurization Flow Control Regulator. The LH_2 control panel supplies 25-psig GN_2 to keep the regulator open when pressurization begins. LH_2 flowing from the storage tank through Vaporizer A3754 is converted to GH_2 and returned to the ullage portion of the tank.

As the ullage pressure rises, Tank Pressurization Regulator A3305 begins closing to reduce the rate of tank pressurization. Controller A3544 effects closing of the regulator by sensing the ullage pressure and supplying a pressure (3 to 15 psig) proportional to the ullage pressure. When the ullage pressure increases to 42 psig, Tank Pressurization Regulator A3305 completely closes to prevent further pressurization. If the ullage pressure increases to 55 psig, Pressure Switch A3538 will energize Solenoid Valve A3387, which vents the 25-psig GN_2 opening pressure to the regulator ensuring that LH_2 flow to Vaporizer A3754 is stopped.

3.5. LH_2 Subcooler (figure 2)

Subcooler A3752, which is a tube-and-shell heat exchanger consisting of a stainless steel vessel enclosed in a steel outer vessel, supercools LH_2 being transferred to the S-IV stage. The inner vessel contains a copper tube bundle, and the annular space between the vessels is insulated and evacuated to 40-micron Hg to minimize heat transfer effects. The subcooler tank is filled with LH_2 during normal transfer operations. When the S-IV stage fuel container reaches 92% full, a signal from Liquid Level Sensor E107 inside S-IV LH_2 Container E102 starts Subcooler Vacuum Pump A3751. The pump evacuates the subcooler tank, or 'shell' ullage space, causing a further temperature drop in the tank. This operation maintains LH_2 temperature between $-423^{\circ}F$ and $-426^{\circ}F$ during the low flow conditions of replenishing.

3.5.1. Liquid Level Probe. Liquid Level Probe A3509 is flange mounted on the top of Subcooler A3752 and extends down into the inner vessels between the tube bundle and the vessel walls. The sensing elements in the stainless steel probe detect the LH_2 level in the inner vessel on a 'continuous' and 'point' basis. A 1/8-inch OD stainless steel tube provides the continuous measurement of LH_2 level. This tube, sealed at the bottom, is connected to a pressure-tight volume chamber mounted in the upper part of the liquid level probe above the flange. The volume chamber and tube are pressurized with GH_2 at 45 psig. As cold LH_2 rises around the tube, GH_2 in the tube condenses, thus lowering the pressure in the tube. When the liquid level drops in the subcooler, a 27-ohm heater wire inside the tube speeds up vaporization of the LH_2, thus raising the tube pressure. The tube pressure, proportional to the LH_2 level, is utilized to maintain a constant liquid level inside the subcooler shell.

Two capacitance sensors, attached to Continuous Probe A3509, provide visual indication of the subcooler LH_2 level by illuminating 'high' or 'low' level lamps on the transducer cabinet and in the LCC.

3.5.2. Pneumatic Pressure Controller. Pneumatic Pressure Controller A3513 controls the signal pressure applied to Pneumatic Subcooler Inlet-Flow Control Regulator A3309 to maintain a constant liquid level inside Subcooler A3752. The controller senses the pressure (normally 10 to 40 psig) in Liquid Level Probe A3509. The controller also receives 25-psig GN_2 from the LH_2 pneumatic control panel and reduces this pressure to a value compatible with liquid level system requirements. When the subcooler LH_2 level rises above a set point, controller output pressure decreases over a range of 3 to 15 psig to close Subcooler Inlet Regulator A3309, which shuts off the LH_2 flow to the subcooler. A decreasing level in the subcooler increases the signal pressure to Controller A3513. The controller output pressure increasing over a range of 3 to 15 psig, opens Subcooler Inlet Regulator A3309 to admit more LH_2 into the subcooler. The liquid level, the controller output, and the regulator continue to cycle until a set equilibrium liquid level is attained. (An alternate method follows: Pneumatic Pressure Controller A3514, used as an alternate for Controller A3513, controls the subcooler LH_2 level by positioning Subcooler Inlet Regulator A3309. Controller A3514 receives a signal inlet pressure of 3 to 15 psig from Pneumatic Pressure Controller A3515, which senses the LH_2 level rise from 0 to 100%. Controller A3514 also receives a 25-psig GN_2 supply pressure from the LH_2 pneumatic panel, which it regulates over a decreasing range of 15 to 3 psig as the signal input pressure rises. The decreasing controller output pressure causes Subcooler Inlet Regulator A3309 to close and shut off LH_2 flow to the subcooler. As the LH_2 level decreases below 100%, Controller A3514 opens Subcooler Inlet Regulator A3309 to permit more LH_2 flow into the subcooler. The alternate liquid level control system cycles until an equilibrium is attained that maintains the necessary amount of LH_2 in the subcooler. The alternate liquid level control system can be isolated from the subcooler by manual valves if it is not needed.)

3.5.3. Pneumatically Operated Flow Control Regulator. Pneumatic Flow Control Regulator A3342 maintains the proper backpressure in the subcooler by limiting the hydrogen flow to the subcooler pump. Valve appearance and operation is similar to that of Pneumatic Tank Pressurization Regulator A3305. Pneumatic Flow Control Regulator A3342 receives 25-psig GN_2 control pressure from the LH_2 pneumatic control panel and 3 to 15 psig signal pressure from Pneumatic Pressure Controller A3515. The controller senses subcooler 'shell' pressure over a range of 0 to 15 psig, and also reduces 25-psig GN_2 pressure from the LH_2 pneumatic control panel, to a value compatible with Flow Control Regulator A3342 requirements. As the 'shell' pressure varies over the range of 3 to 15 psig, the controller repositions the opening of Regulator A3342 and thus varies the flow from the subcooler. The controller and flow control valve cycle until equilibrium is reached and subcooler 'shell' pressure remains constant at the set point.

3.6. LH_2 Pneumatic and Electric Pre-Operational Check (figure 2)

A pre-operations check is initiated to ensure the availability of LH_2 pneumatic control panel supply pressure and electric power to LH_2 control equipment. The LH_2 pneumatic control unit provides GN_2 at 750 and 25 psig for actuation of various LH_2 system pneumatic control equipment, and distributes 25-psig GN_2 through orifices for purging lines and electrical equipment cabinets located in hazardous areas.

3.6.1. LH_2 Pneumatic Control Panel. The pneumatic control panel is placed into operation as follows:

a. Manual Valves A3712, A3713, A3714, A3715, A3720, and A3771 are opened.

b. Manual Vent Valves A3716, A3717, A3718, A3719, A3721, A3722, A3723, and A3724 are closed, except when necessary to relieve pressure from a portion of the cabinet to facilitate repair.

c. Gages A3700, A3701, A3702, and A3703 are monitored to assure that they read 3500, 750, 120, and 25 psig, respectively. Downstream Pressure Regulators A3704, A3705, and A3706 are adjusted to meet pneumatic system pressure requirements.

d. Pressure Switch A3725 actuates on a rising pressure of 600 $\pm$20 psig, illuminating the storage facility '750-psi' indicator on the LCC LH_2 control panel. (Normal line pressure is 750 psig.) Pressure Switch A3711 actuates on a rising pressure of 21.5 $\pm$ 0.5 psig to illuminate the storage facility '25-psi' indicator on the LCC LH_2 control panel. (Normal line pressure is 25 psig.) Pressure Switch A3540 senses the pressure in the 25 psig discharge line and actuates on a rising pressure of 15 psig to supply electric power to the EEH. (Loss of purge and low pressure pneumatic system GN_2 supply during countdown results in the switch closing to shut off the power to all electrically actuated storage facility components.) Relief Valves A3708, A3709, and A3710 provide overpressure protection for the control panel systems.

3.6.2. GN_2 Purge Supply. The GN_2 purge supply to various storage facility and electrical components is tested by a portable manometer for correct pressure and by portable Oxygen Analyzer A3620 for oxygen content of the GN_2. With the storage facility, umbilical tower, and the S-IV stage receiving the purge pressure, tests are performed at various components to determine if the purge is effective. The following list contains the components and test points for connecting the test equipment.

Component	Test Point
Vehicle Vent Stack	Manual Shut-Off Valve A3375
Auxiliary Vent Line	Manual Shut-Off Valve A3374
Launcher Area Transducer Cabinet	Quick-Disconnect Fitting
Storage Facility Vent Line	Manual Shut-Off Valves A3404 and A3366
Steady-State Vent Line	Manual Vent Valve A3416
Subcooler Area Transducer Cabinet	Quick-Disconnect Fitting
Subcooler Pump & Motor	

3.6.3. Electric Power. Power must be available to LH_2 equipment in the EEH, LCC, AGCS, and the storage and launch area burn ponds. The following LCC LH_2 control panel lights are illuminated when proper power is available:

a. ac Power - AGCS AND STORAGE FACILITY.

b. dc Power - STORAGE FACILITY, LCC, AGCS, TOWER S-IV, AND VEHICLE S-IV.

c. Pneumatic Pressure - TOWER S-IV, S-IV 750 PSI, STORAGE FACILITY 25 PSI AND STORAGE FACILITY 750 PSI.

d. Burn Pond Pilots - STORAGE AND LAUNCH FACILITIES.

3.7. S-IV Fuel Container And Transfer Line Purge (figure 3)

Following the pre-operations checkout, the LH_2 system is ready for countdown. A standby period is initiated to permit DAC checkout and a helium purge of the S-IV stage and LH_2 transfer line.

Control of Transfer Line Vent Valve A3308 is transferred to DAC equipment from LCC LH_2 control panel by setting the control return switch to the 'return S-IV control' position. The function selector switch is placed in the 'manual' position. The S-IV status standby light illuminates during this sequence. Helium is supplied to S-IV LOX Tank E152 to maintain its pressure at 29 $\pm$1 psia to prevent collapse of the LOX-LH_2 bulkhead until LH_2 Container E102 purging is complete. LH_2 Container E102 and LH_2 transfer line facilities

are purged with a 50-minute continuous helium purge prior to loading LH_2. Solenoid Valve A2578, energized by a manual command, opens Pre-Pressurization Valve A2539 and allows 50 to 500 psig helium flow through Pre-Pressurization Valve A2539, Check Valve A2580, Manual Shut-Off Valve A2573, Filter A2574, Coupling Halves A3155 and E250, and Check Valve E251 into S-IV LH_2 Container E102. Vent Valves E114 and E115 are closed at this time. Helium flows through Fill and Drain Valve E113 over swing arm No. 2 to the LH_2 main fill and topping control unit. The flow is then routed through either Main Fill Valve A3911 or Replenish Valve A3910 to Helium Heat Exchanger A3950 through Supply Valve A3917 and to LH_2 Subcooler A3752 through Manual Valve A3379. The helium purge supply is vented to the storage facility burn pond through LH_2 Transfer Vent Valve A3308 and through Helium Heat Exchanger A3950 and Line Drain Valve A3912.

Valve panel A supplies 50-psig helium through Solenoid Valve A2321 and Check Valve A2388 into the umbilical vent line and purges LH_2 Quick-Disconnect Couplings A2389 and E105 and the S-IV GH_2 vent stack. Helium then flows through Check Valve A3376 to the launch facility burn pond. Helium from Solenoid Valve A2321 also flows through Filter A2376 and Check Valve A3166 to purge the LH_2 umbilical supply line. Solenoid Valve A2371 supplies 50-psig helium to purge LH_2 Valve A3150 and LH_2 Coupling Half A3159. These purges continue through the cooldown sequence for LH_2 fill. The umbilical line purge removes GH_2 boil-off during cooldown and provides an inert atmosphere in the fill line. The LH_2 nozzle purge displaces GH_2 which might escape from Quick-Disconnect Couplings A2389, E105, A3159, and E100 during LH_2 fill and provides an inert atmosphere in the immediate areas around the disconnect couplings. The inert gas in the S-IV transfer line fuel system are tested to determine the helium content. The tests must indicate more than 99% helium before the system can be declared in a state of readiness for LH_2 loading. When the S-IV stage is ready for LOX and LH_2 loading operations, a signal is sent to KSC and the S-IV 'control return' light on the LCC LH_2 control panel goes out.

4. LH_2 FILL OPERATIONS

The LH_2 fill operations are undertaken during prelaunch countdown to supply LH_2 to the S-IV stage fuel container. Fill operations include S-IV LOX container and LH_2 storage tank pressurization, transfer line cooldown, main fill, replenish, and final replenish sequences. The various sequences of operation progress automatically after initiation by LCC control equipment.

Depressing the 'fill' pushbutton on the LCC LH_2 control panel initiates main LH_2 transfer. The LCC LH_2 control panel 'standby' indicator goes out and the 'fill' light illuminates on the fill sequence group of indicators. Pneumatic Subcooler Back Pressure Regulator A3342 is opened and its position is monitored on the LCC LH_2 components panel by the 'subcooler back pressure open' indicator. The LH_2 fill command signals DAC equipment to pressurize S-IV stage LOX Container E152 and also illuminates the LH_2 control panel

'pressurize S-IV LOX tank' indicator. LOX container pressurization to 45-48 psia prevents collapse of the LOX-LH_2 bulkhead as LH_2 is loaded. The 'pressurized complete' light on the LCC LH_2 control panel illuminates when container pressurization terminates (described in Volume II).

4.1. LH_2 Storage Tank Pressurization (figure 2)

After the LOX container has been pressurized, the transfer sequence progresses automatically to LH_2 storage tank pressurization. The LH_2 control panel 'pressurize storage tank' indicator is illuminated. Interlocks 1 and 2 are used (refer to LH_2 System Interlocks for a description, page 26).

Controller A3544 and Solenoid Valve A3387 open Pneumatic Tank Pressurization Regulator A3305. Valve opening is monitored by the LH_2 components panel 'tank pressurization open' indicator. LH_2 from Storage Tank A3753 passes through Shut-Off Valve A3301, Pneumatic Tank Pressurization Regulator A3305, and Vaporizer A3754 where it is converted to GH_2 for storage tank pressurization. Relief Valve A3641 vents excess line pressure to the tank pressurization line downstream from Vaporizer A3754, maintaining vaporizer and regulator upstream and downstream pressures within a differential pressure of 20 psig. Pneumatic Tank Pressurization Regulator A3305 flow area is reduced by Controller A3544 as tank pressure rises, until the valve is completely closed at about 42 psig ullage pressure. Pressure switch A3537 illuminates the LCC LH_2 control panel 'pressurize completed' indicator when storage tank pressure rises to 30 psig, and the 'pressure storage tank' indicator goes out. Pressure Switch A3538 actuates at an increasing ullage pressure of 55 psig to remove the power from Solenoid Valve A3387. Solenoid Valve A3387 closing provides redundancy for Controller A3544 by ensuring that Pneumatic Tank Pressurization Regulator A3305 is completely closed. Pressure Gage A3532 allows local monitoring of storage tank ullage pressure over a range of 0 to 100 psig. Pressure Transducer A3533 provides a signal for remote monitoring of the ullage pressure.

Continued ullage pressure rise to 60 psig actuates Pressure Switch A3539. Switch actuation supplies power to Solenoid Valves A3395 and A3396, which opens Pneumatic Vent Valve A3304. Excess tank pressure is vented through Pneumatic Vent Valve A3304 and Check Valve A3365 to the storage facility burn pond. Ullage pressure is maintained at approximately 42 psig for the duration of LH_2 transfer.

Relief Valve A3640 provides overpressure protection for the storage tank vent line by relieving excess pressure at 100 psig to the storage area burn pond. Burst Discs A3630 and A3631 provide redundancy for Relief Valve A3640 by relieving excess pressure at 115 to 120 psig. (Manual Shut-Off Valve A3319 can be adjusted to isolate either rupture disc while placing the remaining disc in operation.) Vent line pressure is monitored locally by Pressure Gage A3549.

4.2. Transfer Line Cooldown (figure 3)

Thirty seconds after Pneumatic Tank Pressurization Regulator A3305 opens, a timer automatically initiates the transfer line cooldown sequence and the LH_2 control panel 'cooldown fill line' indicator illuminates. (Interlocks 1, 2, 3, 4, 5, and 6 are used.) The LH_2 storage tank has been pressurized to 42 psig. Umbilical purge Solenoid Valve A2321 and LH_2 coupling assembly purge Solenoid Valve A2371, located in valve panel A; Umbilical Drain Valve A3912; Manual Shut-Off Valve A3379; and Supply Valve A3303 are opened. The helium precool heat exchanger level sensor switch is placed in the 'on' position, and helium precool heat exchanger Supply Valve A3917 is locked open to bypass the normal sensor control of the valve. LH_2 Transfer Line Cooldown Valve A3307 and LH_2 Replenish Valve A3910 are opened. LH_2 flows from Storage Tank A3753 through the subcooler, transfer line, and LH_2 main fill and topping control to precool the lines. Cooldown operation continues until a temperature of $-420^{\circ}F$ has been indicated for a minimum of 15 seconds. When this condition has been met, Replenish Valve A3910 is closed. GH_2 vent line pressure, measured by Pressure Switch A3588, should not be allowed to exceed 25 psia during cooldown operation.

After the $-420^{\circ}F$ temperature has been indicated for 15 seconds and the liquid level sensor in the helium precool heat exchanger has indicated a 'high' or 'maximum' LH_2 level for 5 seconds, the lock-open bypass of the liquid level sensor is removed, allowing the sensor to initiate the closing of helium precool heat exchanger Supply Valve A3917. The heat exchanger level sensor circuitry is then disarmed causing Supply Valve A3917 to remain closed to prevent LH_2 demand by the heat exchanger during LH_2 flow to vehicle 15% mass level. Umbilical purge Solenoid Valve A2321 and Umbilical Drain Valve A3912 are closed. LH_2 container Vent Valves E114 and E115 and Fill and Drain Valve E113 are opened. Replenish Valve A3910 again opens. LH_2 transfers to the vehicle at approximately 450 gpm filling the LH_2 container to the 15% mass level.

4.3. Main Fill (figures 2 and 3)

A 15% mass level indication automatically initiates the main fill sequence of the S-IV stage LH_2 container and illuminates the 'main fill' indicator on the LH_2 control panel. (Interlocks 1, 2, 3, 4, 5, 6, and 7 are used.)

Transfer Line Fill Valve A3306 opens and Transfer Line Cooldown Valve A3307 remains open. The S-IV stage LH_2 container is monitored for stable pressure condition. LH_2 flows from the Storage Tank A3753 through Supply Valve A3303, Transfer Line Fill Valve A3306 and Transfer Line Cooldown Valve A3307, Subcooler A3752, Shut-Off Valve A3379 (figure 3), Main Fill Valve A3911 and Replenish Valve A3910, Filter A3905, LH_2 Valve A3150, LH_2 Coupling Half A3159, Nozzle E100, and Fill and Drain Valve E113 into the S-IV stage container. Filling rate is approximately 2,000 gpm. Helium precool heat exchanger circuitry is rearmed to allow the sensor to maintain the proper LH_2 level in the heat exchanger tank. Relief Valves A3642 and A3646 (figure 2) provide overpressure protection for the transfer line by venting excess

pressure at 100 psig to the storage facility burn pond and to the launch facility burn pond, respectively.

4.3.1. Subcooler Operation. Subcooler operation begins during the main fill sequence and continues throughout replenish and final replenish sequences (described in paragraphs 4.4 and 4.5).

When the S-IV stage LH_2 fuel container has been filled to 92%, Sensor E107 illuminates the '92%' tank level indicator on the LH_2 components panel and DAC automatic circuitry initiates a start command to Subcooler Vacuum Pump A3751 and Subcooler Vacuum Pump Motor A3939. Solenoid Valve A3386 opens permitting Pneumatic Subcooler Inlet Regulator A3309 to function. Liquid Level Probe A3509 senses a low subcooler liquid level and supplies a high pressure signal to open Pneumatic Controller A3513. GN_2 flows from the controller through Manual Shut-Off Valve A3412 and opens Pneumatic Subcooler Inlet Regulator A3309, which admits transfer line LH_2 into the subcooler shell. As the LH_2 rises inside the shell, Liquid Level Probe A3509 supplies a lower pressure signal, which begins closing Pneumatic Controller A3513. The drop in controller output pressure over a range of 15 to 3 psig begins closing Pneumatic Subcooler Inlet Regulator A3309, thus reducing the LH_2 flow into the subcooler shell. The sensor, controller, and regulator continue to cycle until a predetermined LH_2 level is attained. (The alternate liquid level system provides redundancy in case Liquid Level Probe A3509 or Controller A3513 should fail during transfer operations. The alternate system is activated by closing Shut-Off Valves A3413, A3384, A3385, A3406, and A3407. The Controller A3515 senses shell LH_2 differential pressure and supplies a 3 to 15 psig signal to Controller A3514 as the LH_2 rises from 0 to 100%. Controller A3514 converts the 3 to 15 psig signal to a 15 to 3 psig output for controlling the position of Subcooler Inlet Regulator A3309. If it becomes necessary to deactivate Controller A3515 for a short period of time, Shut-Off Valve A3405 may be opened to equalize the pressure across the controller sensing element. Closing the shut-off valve places the controller back into operation.)

The LH_2 level in the subcooler shell is monitored remotely by an indicator on the LCC LH_2 monitor panel. The indicator receives signals from Pressure Transducer A3507 that are proportional to pressure inside Liquid Level Probe A3509. (Pressure Gage A3506 is used to check and calibrate instruments in the subcooler liquid level circuit.) Subcooler shell vacuum is monitored by Vacuum Transducer A3623. Vacuum Pump A3751 operation reduces the pressure above the LH_2 in the subcooler shell below ambient. The resulting pressure drop lowers the shell temperature enough to supercool the transfer line LH_2 from $-423^{\circ}F$ to approximately $-426^{\circ}F$. The supercooling effect, initiated when Fuel Container E102 level reaches 92%, reduces boil-off during the slower rate of replenishing.

Solenoid Valve A3388 opens when Vacuum Pump Motor A3939 starts to permit Pneumatic Controller A3554 to regulate the position of Subcooler Back Pressure Regulator A3342. The controller senses subcooler shell vacuum and positions Regulator A3342 to maintain the vacuum at a constant predetermined value, thus

controlling the rate of evacuation by Vacuum Pump A3751. The vacuum pump discharges GH_2 through the main vent line and Check Valve A3349 into the storage facility burn pond. Relief Valve A3645 provides overpressure protection for the vacuum line by relieving excess pressure at 5 psig to the storage facility burn pond. Check Valve A3402 releases GN_2 purge gas from the housing of Vacuum Pump A3751 and prevents reverse flow of atmospheric air. Temperature Sensor A3585 and Indicator A3584 allow local monitoring of vacuum line temperature. Temperature Sensor A3587 and Indicator A3586 allow local monitoring of vacuum pump inlet temperature. Pressure Transducer A3547 and an indicator in the LCC allow remote monitoring of the subcooler vacuum.

4.3.2. Monitor of LH_2 Flow. Monitoring of associated LH_2 transfer operations is provided for three major areas: subcooler inlet, subcooler outlet, and transfer line outlet. Subcooler inlet Temperature Sensor A3574 measures the line temperature upstream from Subcooler A3752. Measuring instruments associated with the sensor measure the vapor pressure inside the sensor bulb and provide a temperature indication, which corresponds to a given vapor pressure. Temperature Indicator A3571 provides a visual indication of Sensor A3574 fill measurements (and is used to calibrate Temperature Transducer A3572 when necessary). Temperature Transducer A3572 provides remote monitoring of subcooler inlet temperature. Subcooler discharge Temperature Sensor A3583 provides a temperature measurement for Temperature Indicator A3582. Temperature Indicator A3582 monitors subcooler discharge temperature over a range of -403°F to -430°F. Transfer line outlet Temperature Sensor A3580 (figure 3) provides a temperature measurement for temperature indicating components. Sensor operation is similar to that of Sensors A3583 and A3574. Temperature Indicator A3576 monitors transfer line outlet temperature (and is used to calibrate Temperature Transducer A3578 when necessary). Temperature Transducer A3578 provides LCC monitoring of transfer line outlet temperature by a temperature recorder and an LH_2 monitor panel temperature indicator. Transducer A3624 monitors pressure in the transfer line vacuum jackets in the transfer line outlet area.

4.3.3. Main Fill Termination. When the LH_2 container has been filled to 95%, Solenoid Valve A3906 closes Main Fill Valve A3911, which stops the 2000 gpm LH_2 flow into the container. The '95%' container level indicator on the LH_2 components panel illuminates, indicating that the main fill sequence has terminated. Transfer Fill Valve A3306 is closed 15 seconds after Main Fill Valve A3911. The 'main fill completed' indicator on the LH_2 control panel comes on and the 'main fill' indicator goes out when Main Fill Valve A3911 closes.

4.4. Replenish (figures 2 and 3)

Replenish sequence begins automatically at termination of the main fill sequence by a 95% full signal from the DAC propellant utilization system and by the closing of Main Fill Valve A3911. The replenish indicator on the LH_2 control panel comes on. (Interlocks 1, 2, 3, 4, 5, 6, and 7 are used.)

Transfer Line Fill Valve A3306 has been closed and LH_2 transfers through Transfer Line Cooldown A3307 and Replenish Valve A3910 into the S-IV stage container at 450 gpm. At the 99.8% mass level indication, Replenish Valve A3910 closes to the reduced position and cycles between the reduced and open position as commanded by the propellant loading computer to maintain liquid level between the 99.4% and 99.8% mass levels. At this time S-IV stage LH_2 and LOX systems controls are transferred to DAC equipment.

During both main fill and replenish operations, Main Fill Valve A3911 is controlled by 750-psig GN_2 pneumatic pressure admitted to the valve actuator by Solenoid Valve A3906. Solenoid Valves A3923 and A3922 control the position of Replenish Valve A3910. Solenoid Valve A3923 controls full opening of the pneumatic valve for 450 gpm replenishing, and Solenoid Valve A3922 controls intermediate opening of the replenish valve for reduced flow replenishing. During transfer operations, Pressure Transducers A3900 and A3916 provide main fill and topping control unit line pressure signals to an indicator on the LH_2 monitor panel in the LCC. Differential Pressure Transducer A3949 provides remote monitoring of the pressure drop across Filter A3905 by supplying signals to a filter differential pressure indicator also mounted on the LCC LH_2 monitor panel. Line pressure and filter pressure drop measurement ranges are 0 to 100 psig and 0 to 30 psig, respectively. Relief Valve A3932 provides overpressure protection for the main fill and topping control by venting excess pressure at 92 $\pm$2 psig to the launch area burn pond.

4.5. Final Replenish (figures 2 and 3)

Final replenish and LH_2 Container E102 pre-pressurization begins 10 seconds after the initiation of fire command at 150 seconds before liftoff (T -150). The final replenish operation fills the LH_2 container to 100% full just before liftoff. (Interlocks 1, 2, 3, 4, 5, 6, and 7 are used.)

Pneumatic Vent Valves E114 and E115 are closed by Solenoid Valves E209 and E210 at T -140 seconds. The vent valves closed signal opens S-IV Pre-Pressurization Valve A2539 in valve panel B. Through Coupling Halves A3155 and E250 and Check Valve E251, 50 to 500-psig helium flows into the LH_2 fuel container thus beginning container pre-pressurization. When LH_2 final replenish is initiated, Solenoid Valve A3923 completely opens Replenish Valve A3910 to supply LH_2 to the fuel container at approximately 450 gpm.

A command signal to Solenoid Valve E211 at T -135 seconds boost closes Pneumatic Vent Valves E114 and E115. The signal is withdrawn at T -130 seconds.

At approximately T -90 seconds, the S-IV fuel container is completely replenished and DAC automatic circuitry closes Replenish Valve A3910 and Fill and Drain Valve E113. The 'replenish completed' indicator on the LCC LH_2 control panel and the '100%' container level indicator on the LH_2 components panel illuminate.

When container pressure reaches 37.25 $\pm$0.75 psia, Pressure Switch E276 actuates to close Pre-Pressurization Valve A2539. Switch deactuation at

35.75 ±0.75 psia opens the pre-pressurization valve if container pressure should drop before launch. After the fuel container has been filled with LH_2 and completely pressurized, Solenoid Valve A3925 opens main fill and topping control Line Drain Valve A3912. LH_2 in the transfer line vents through Check Valve A3378 to the launch facility burn pond. The vent valve open signal opens Helium Purge Solenoid Valve A2321. A 50-psig helium purge from valve panel A enters the transfer line and flows through Check Valve A3166, Filter A3905, Line Drain Valve A3912 and into the launch facility vent stack through Check Valve A3378. Vacuum Pump A3751 stops, Solenoid Valve A3386 closes Pneumatic Subcooler Inlet Regulator A3309, and Solenoid Valve A3931 closes Pneumatic Heat Exchanger LH_2 Inlet Supply Valve A3917 when S-IV Fuel Container E102 is 100% full. If Pneumatic Subcooler Inlet Regulator A3309 or Supply Valve A3917 do not close within 10 seconds, Transfer Line Fill Valve A3306 will close to shut off LH_2 flow.

A first motion signal resulting from vehicle liftoff disconnects the ground fill, vent, and pressurization attachments as described in Volume VII. Line Drain Valve A3912 is closed by DAC automatic circuitry. One minute after liftoff, Helium Purge Solenoid Valve A2321 is closed by DAC automatic circuitry. Valve positions are monitored by the appropriate 'closed' indicators on the LH_2 components panel. The LH_2 storage facility remains in this condition for two minutes, after which time a secure command may be given.

5. FLIGHT

Fuel container pressurization improves container structural integrity and provides a net positive suction head compatible with RL10A-3 engine turbopump inlet requirements. Four levels of container pressurization, applicable to flight requirements, are initiated between ground LH_2 replenish operations and RL10A-3 engine shutdown.

S-IV stage LH_2 consumption begins with RL10A-3 engine cooldown, prior to ignition.

5.1. S-IV Fuel Container Pressurization (figure 3)

S-IV Fuel Container E102 is pre-pressurized to a nominal pressure of 36.5 psia during replenish operations when the fuel container level reaches 95%. Pressure Switch E276 maintains pre-pressurization between 37.25 ±0.75 psia and 35.75 ±0.75 psia by controlling the opening of LH_2 pre-pressurization Solenoid Valve A2539 in valve panel B. Immediately before liftoff, Pressure Switch E278 signals inadequate container pressure for liftoff if container pressure drops to 33.5 ±0.5 psia, and launch is halted. However, if pressure is 34.5 ±0.5 psia, the pressure switch signals minimum pressure for liftoff, and the flight proceeds. Fuel container pressure remains substantially constant during S-I powered flight, and the make-up pressure sphere is locked out until LH_2 prestart command is initiated. An appreciable ullage pressure drop occurs, however, when LH_2 begins flowing to the RL10A-3 engines during

LH_2 prestart operation (described in Volume IX). Pressure Switch E277 opens Solenoid Valves E257 and E255 to admit make-up pressure to Fuel Container E102 if pressure drops to 30.5 ±0.5 psia. Helium at 3000 psig, supplied by Sphere E218 through Solenoid Valve E257, Check Valve E258, Orifices E259 and E253, Solenoid Valve E255, and Orifice E256, increases container pressure to 31.5 ±0.5 psia; then make-up pressurization stops. Pressure Switch E277 controls container pressurization between 30.5 ±0.5 psia and 31.5 ±0.5 psia. If the make-up pressurization system cannot maintain container pressure because of the high flowrate of LH_2 from the container, an additional pressurization capability is provided by Step-Pressure Switch E279 and Solenoid Valve E254. Step-Pressure Switch E279 will actuate when the container pressure decreases below 27.5 ±0.5 psia and will energize Solenoid Valve E254, which allows a higher flowrate of helium from the make-up pressurization sphere into the LH_2 container. When container pressure rises above 29.5 ±0.5 psia, Step-Pressure Switch E279 will de-energize Solenoid Valve E254. Pressure Switch E277 will then assume control of container pressurization until prestart operations have been completed. A system interlock, at engine out capability arming (5.4 seconds after S-I stage outboard engine cutoff and described in Volume X), renders the make-up pressurization system inoperative for the remainder of the S-IV powered flight.

After engine ignition, fuel container pressurization is supplied by 340-psia GH_2 from the RL10A-3 bleed network. The pressure, reduced to about 34 psig maximum by Orifice E253, helps maintain adequate container pressurization as LH_2 is depleted. Solenoid Valve E255 supplies additional GH_2 to the fuel container through Orifice E256 upon receipt of a command signal from Pressure Switch E277 when container pressure drops below 30.5 ±0.5 psia. Pressure Switch E277 controls the opening and closing of the solenoid valve, maintaining a container pressure of 30.5 ±0.5 psia to 31.5 ±0.5 psia until approximately 370 seconds after RL10A-3 engine ignition.

Additional fuel container pressurization is required during the last 100 seconds of powered flight to ensure that a net positive suction head will be maintained at the RL10A-3 engine turbopump inlets. Approximately 370 seconds after engine ignition (with approximately 21% LH_2 remaining), the propellant utilization system energizes Solenoid Valve E254, supplying additional GH_2 to the LH_2 container. An increase in nominal container pressure to about 10 psig is made possible by admitting 340-psia GH_2 from the RL10A-3 engine bleed system through Solenoid Valve E254 and Orifice E252, which is comparatively larger in diameter than the other two container pressurization orifices (E253 and E256). Container pressurization is maintained during the remainder of powered flight by Solenoid Valve E254 and Orifice E252 and through Orifice E253.

During flight, a small differential pressure is maintained between the LH_2 and LOX containers to prevent possible collapse of the LH_2-LOX bulkhead. The differential pressure is controlled by venting excess pressure from the LH_2 container. If the LH_2 container pressure exceeds the LOX container pressure by 4 ±1 psig, Differential Pressure Switch E275 signals Solenoid Valve E209 to open Vent Valve E115. GH_2 vents from the LH_2 container until the

differential pressure has been reduced to 2 ±1 psig. The pressure switch then signals Solenoid Valve E209 to close Vent Valve E115. Pneumatic Vent Valves E114 and E115 provide overpressure protection for LH_2 Fuel Container E102 during flight by relieving excess pressure at 44 psia maximum; reseat pressure is 41 psia maximum.

5.2. LH_2 Consumption (figure 3)

LH_2 consumption is initiated during RL10A-3 engine cooldown. A pneumatic fuel inlet shut-off valve in each engine suction line is opened by a prestart solenoid valve during the S-I - S-IV stage separation sequence (described in Volume IX). LH_2 flows from Fuel Container E102, through each of the six suction lines and fuel inlet valves to a turbopump on each RL10A-3 engine. Mass flowrate to each engine after ignition is approximately 5.88 pounds per second at a nominal LOX-LH_2 mixture ratio of 5 to 1. Engine cutoff is initiated by the S-IV propellant utilization system, which receives a command signal from Sensor E107 when the LH_2 has been depleted to approximately 83 pounds residual fuel.

6. LH_2 DRAIN

During or after fill operations, it may be necessary to drain LH_2 from the S-IV fuel container to the ground storage tank.

The prerequisites for draining are the same as for loading except that S-IV status for loading is replaced by status for draining. The 'standby' indicator, in the drain group of indicators on the LCC LH_2 control panel, will light when the system is ready for draining.

After the 'drain' pushbutton on the LH_2 control panel has been depressed, the drain sequence proceeds automatically and includes: storage tank depressurization, S-IV LH_2 fuel container pressurization, S-IV LH_2 fuel container drain, transfer line warm-up, and manual inerting. The drain 'standby' indicator goes out and the 'drain' sequence indicator illuminates. Pressurization of the S-IV LOX container (described in Volume II) begins at this time.

6.1. Storage Tank De-Pressurization (figure 2)

Before LH_2 is drained from the S-IV fuel container, the storage tank ullage pressure must be vented to the storage facility burn pond and the pressurization equipment must be shut down. (Interlock 6 is used.)

Subcooler Inlet Regulator A3309 and Helium Precool Heat Exchanger Supply Valve A3917 close. (If either valve fails to close within 10 seconds, Transfer Line Fill Valve A3306 will close to prevent further LH_2 transfer and the drain sequence will stop.) Solenoid Valve A3387 closes Vaporizer Inlet Regulator A3305 to prevent further storage tank pressurization, Solenoid Valves A3923 and A3922 close Replenish Valve A3910, and Solenoid Valve

A3906 closes Main Fill Valve A3911. (If the replenish valve and the fill valve do not close within 15 seconds, Transfer Line Fill Valve A3306 will close.) Fill and Drain Valve E113 opens. A closed signal from Vaporizer Inlet Regulator A3305 opens Pneumatic Vent Valve A3304 and the 'vent storage tank' indicator on the LH_2 control panel illuminates. The storage tank vents to the storage facility burn pond through Pneumatic Vent Valve A3304 and Check Valve A3365. When storage tank ullage pressure drops to 2 psig, Pressure Switch A3535 actuates and illuminates the 'vent completed' indicator on the LCC LH_2 control panel.

6.2. S-IV LH_2 Fuel Container Pressurization (figure 3)

When storage tank pressure drops to 8 psig or less, the S-IV LH_2 fuel container pressurization begins. The 'pressurize S-IV tank' indicator on the LH_2 control panel illuminates. (Interlocks 3, 6, and 11 are used.)

Vent Valves E114 and E115 are closed to prepare LH_2 Fuel Container E102 for pressurization. A closed feedback signal from the vent valves opens LH_2 pre-pressurization Solenoid Valve A2539 in valve panel B. Valve positions are displayed by the appropriate indicators on the LH_2 components panel. Helium at 50 to 500 psig enters the fuel container through Coupling Halves A3155 and E250 and Check Valve E251. When the container has been pressurized to 17 psig, a 'pressurize completed' indicator on the LH_2 control panel illuminates.

6.3. S-IV LH_2 Fuel Container Drain (figure 3)

S-IV fuel container draining begins when pressure increases to 17 psig or more. (Interlocks 3, 6, and 11 are used.)

Transfer Line Fill Valve A3306 is opened if closure occurred during storage tank de-pressurization or the S-IV LH_2 Fuel Container Pressurization part of the drain sequence. Main Fill Valve A3911 and Fill and Drain Valve E113 open and the 'drain' indicator on the LH_2 control panel illuminates. LH_2 flows from the LH_2 vehicle container through Fill and Drain Valve E113, Nozzle E100, Coupling Half A3159, LH_2 Valve A3150, Filter A3905, Main Fill Valve A3911, Shut-Off Valve A3379, Subcooler A3752, Transfer Line Fill Valve A3306, and Supply Valve A3303 into Storage Tank A3753. Temperature Switch A3575 actuates at an increasing transfer line temperature of -406°F and signals the completion of draining. The 'drain completed' indicator on the LCC LH_2 control panel illuminates.

6.4. Line Warm-Up (figure 2)

The sequence is initiated when transfer line inlet temperature increases to -406°F or higher, illuminating the 'line warm-up' indicator on the LH_2 control panel. (Interlocks 3, 6, and 11 are used.)

Transfer Line Fill Valve A3306 and pneumatic Main Fill Valve A3911 close. Control is returned to DAC equipment when a closed feedback signal is received

from Main Fill Valve A3911. LH_2 Container pre-pressurization Solenoid Valve A2539 in valve panel B closes to stop further container pressurization. Transfer Line Vent Valve A3308 opens to vent the transfer line to the storage facility burn pond. Vent Valve A3304 is closed by a feedback signal from Pressure Switch A3535 when Storage Tank A3753 pressure drops to 2 psig or less, or by a closed feedback signal from Transfer Line Fill Valve A3306. The transfer line is vented for three hours after the previous commands have been given. Pneumatic Transfer Line Vent Valve A3308 then closes and line warm-up automatic sequencing terminates. The 'line warm-up' indicator, on the LH_2 control panel, goes out.

6.5. Manual Inerting (figure 2)

Manual 'inerting' of the storage facility is initiated when Pneumatic Transfer Line Vent Valve A3308 closes. The 'ready for inerting' indicator on the LCC LH_2 control panel illuminates. The sequence is the same as the manual 'inerting' performed during secure operations (paragraph 7.3.).

7. SECURE OPERATIONS

The secure sequence provides shutdown of the LH_2 storage facility after vehicle launch. When the LH_2 storage facility is ready for the secure sequence, the 'standby' light in the secure group of indicators on the LCC LH_2 control panel illuminates.

The prerequisites for secure operation are the same as the prerequisites for LH_2 loading except:

a. The S-IV 'status for loading' indicator on the LH_2 control panel is out.

b. Pneumatic Helium Heat Exchanger LH_2 Inlet Valve A3917 (figure 3) is closed.

c. Transfer line Helium Purge Solenoid Valve A3318 is closed if it has not already been manually closed.

The secure operations begin with storage tank venting which occurs when the 'secure' pushbutton, on the LCC LH_2 control panel, is depressed. The LH_2 control panel 'secure' indicator illuminates and the 'standby' indicator goes out, and an S-IV LH_2 secure command is given to DAC. (Interlocks 1 and 6 are used.)

Vaporizer Inlet Regulator A3305 (figure 2) is closed and the closed feedback signal opens Vent Valve A3304. Storage Tank A3753 vents to the storage facility burn pond through Check Valve A3365. Pressure Switch A3535 actuates and illuminates the 'vent completed' indicator on the LCC LH_2 control panel when storage tank ullage pressure decreases to 2 psig.

7.1. Transfer Line Drain (figure 2)

This sequence is initiated when Vent Valve A3304 opens to drain LH_2 from the transfer line into the storage tank. The 'drain' indicator on the LH_2 control panel illuminates. (Interlocks 3, 6, 8, and 9 are used.) Solenoid Valves A3318 and A3344 are opened for two minutes to allow 50-psig helium to accelerate draining operations by forcing LH_2 back to the storage tank. LH_2 drains back to the storage tank through Shut-Off Valve A3379, Subcooler A3752, Transfer Line Fill Valve A3306, and Supply Valve A3303.

7.2. Line Warm-Up (figure 2)

This sequence is initiated when transfer line inlet temperature is $-406^{\circ}F$ or higher. (Interlocks 3, 6, and 10 are used.)

Transfer Line Fill Valve A3306 closes. The 'line drain completed' and 'line warm-up' indicators on the LH_2 control panel illuminate and the 'line drain' indicator goes out. Solenoid Valves A3394 and A3393 open Transfer Line Vent Valve A3308, which vents the transfer line to the storage facility burn pond through the vent valve. If Vent Valve A3308 should fail, Relief Valve A3643 provides overpressure protection for the transfer line by relieving excess pressure at 100 psig to the storage facility burn pond. Storage Tank Vent Valve A3304 closes when storage tank pressure decreases to 2 psig or less and is also interlocked closed with the closing of Vaporizer Inlet Regulator A3305 and Transfer Line Fill Valve A3306. Three hours after the preceding commands have been given, Vent Valve A3308 closes and the automatic sequencing ends. The 'ready for inerting' indicator on the LCC LH_2 control panel illuminates.

7.3. Manual Inerting (figure 2)

This sequence begins at the termination of the line drain sequence to provide an inert atmosphere throughout the LH_2 transfer system. Solenoid Valve A3318 is closed manually from the LH_2 components panel. Manual Valves A3301, A3303, and A3343 are closed. Shut-Off Valves A3336 and A3337 are opened to supply low pressure GN_2 to the transfer line. The GN_2, supplied at Coupling Half A3937, passes through Shut-Off Valve A3337, Orifice A3606, Shut-Off Valve A3336, and Check Valve A3348 into the Transfer Line. Helium Heat Exchanger LH_2 Inlet Valve A3917 is opened for one hour and Subcooler Inlet Regulator A3309 is opened for five minutes. GN_2 from the transfer line purges Helium Heat Exchanger A3950 and Subcooler A3752. Pneumatic valve and regulator positions are displayed on the appropriate indicators on the LH_2 components panel. Pneumatic Controller A3551 opens Steady-State Vent Regulator A3338 to vent down the Storage Tank A3653. Tank pressure may be maintained at a positive pressure of about 0.5 psig by adjusting Controller A3551.

8. LH_2 SYSTEM INTERLOCKS

The following relationships exist between components (or components and system conditions) in the LH_2 system:

1. Pneumatic Transfer Line Fill Valve A3306 is closed until opened by the 15% load level signal from S-IV LH_2 container.

2. Pneumatic Transfer Line Fill Valve A3306, S-IV Pneumatic Replenish Valve A3910, and S-IV Pneumatic Main Fill Valve A3911 are closed unless the S-IV LOX tank is pressurized. The LOX tank pressurized signal is supplied by DAC.

3. Pneumatic Transfer Line Fill Valve A3306 and Pneumatic Transfer Line Cooldown Valve A3307 close with the opening of Pneumatic Transfer Line Vent Valve A3308.

4. S-IV Pneumatic Replenish Valve A3910 and S-IV Pneumatic Main Fill Valve A3911 close with S-IV LH_2 container overpressure indication.

5. S-IV Pneumatic Replenish Valve A3910 and S-IV Pneumatic Main Fill Valve A3911 close with S-IV overfill indication.

6. S-IV Pneumatic Umbilical Line Vent Valve A3912 is interlocked closed by DAC circuitry with the opening of Pneumatic Main Fill Valve A3911 or S-IV Pneumatic Fill and Drain Valve E113.

7. Pneumatic Transfer Line Fill Valve A3306 is interlocked closed with the closing of S-IV Pneumatic Vent Valves E114 and E115.

8. Solenoid Transfer Line Helium Purge Valve A3318 and Solenoid Transfer Line High Pressure Helium Purge Valve A3344 are closed with the opening of either Pneumatic Subcooler Inlet Valve A3309 or S-IV Pneumatic Helium Heat Exchanger LH_2 Inlet Valve A3917.

9. LH_2 storage tank pressure less than 30 psig opens Solenoid LH_2 Transfer Line Helium Purge Valve A3318 or Solenoid LH_2 Transfer Line High Pressure Helium Purge Valve A3344.

10. LH_2 Tank Pneumatic Main Vent Valve A3304 is closed when LH_2 storage tank pressure is equal to or less than 2 psig and the valve is interlocked closed with Pneumatic LH_2 Storage Tank Pressurization Valve A3305 and Pneumatic Transfer Line Fill Valve A3306.

11. Pneumatic S-IV LH_2 Container Pressurization Valve A2539 is closed unless S-IV LOX tank is pressurized.

LIST OF FINDING NUMBERS

*	FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
	A2388	1	Valve, Check				
	A2389	1	Coupling Half		Douglas Aircraft Co.		
	A2390 through A3149 are not functionally applicable to this system.						
	A3150	1	Valve	3 in., 2000 gpm @ 70 psia, N.O.	B. H. Hadley Inc. PN11409-1	75M05605	57A12A22
	A3151 through A3154 are not functionally applicable to this system.						
	A3155	1	Coupling Half	Fuel Pressure		75M05195	
	A3156 through A3158 are not functionally applicable to this system.						
	A3159	1	Coupling Half	LH_2 Supply		75M04852	
	A3160 through A3165 are not functionally applicable to this system.						
	A3166	1	Valve, Check	Helium Purge	Douglas Aircraft Co. PN3871261-501		
	A3167	1	Orifice	Valve Purge		75M06713-2	
	A3168	1	Orifice	LH_2 Coupling Assembly Purge		75M06686-3	

*Location: A = Ground; B = S-I Stage; E = S-IV Stage; G = Instrument Unit; H = Payload.

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3169 through A3300 are not functionally applicable to this system.						
A3301	1	Valve, Manual	3 in., Shut-Off	Pacific Valves, Inc. Model G-710YJ-10K-WE	10464405	
A3302	1	Valve, Pneumatic	2 in., N.C., Tank Fill	The Annin Co. Model 1720	10464408	50A23
A3303	1	Valve, Manual	6 in., Supply	Pacific Valves, Inc. Model G-710YJ-10K-WE	10464407	
A3304	1	Valve, Pneumatic	8 in., N.C., Vent	The Annin Co. Model 1620B	10464411	50A20
A3305	1	Regulator, Pneumatic Flow Control	25 psig Actuator Pressure, 3-15 psig Signal Pressure, 1 1/2 in., N.C.	The Annin Co. Model 1760	10464410	50A11
A3306	1	Valve, Pneumatic	6 in., N.C., Transfer Line Fill	Pacific Valves, Inc. Model G-710YJC-10K-WE	10464401	50A26
A3307	1	Valve, Pneumatic	1 1/2 in., N.C., Cooldown	The Annin Co. Model 1720	10464402	50A29
A3308	1	Valve, Pneumatic	1 1/2 in., N.C., Transfer Line Vent	The Annin Co. Model 1620	10464403	50A32
A3309	1	Regulator, Pneumatic Flow Control	25 psig Actuator Pressure, 3-15 psig Signal Pressure, 1 in., N.C.	The Annin Co. Model 1760	10464416	50A13
A3310 through A3317 are not functionally applicable to this system.						
A3318	1	Valve, Solenoid	2 way, 2 position, N.C.	Marotta Valve Corp. Model MV-185	10464427	57A3A3

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3319	1	Valve, Manual	3 way, 2 in., Shut-Off	Duriron Co. Model FG-321	10464557	
A3320	1	Valve, Manual	2 in., Fill	The Annin Co. Model 1710	10464409	
A3321						
A3322	1	Valve, Manual	1/2 in., Shut-Off	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3323	1	Valve, Manual	3 in.	Hills Mc Canna Co. Model S-303-S6-T	10464562	
A3324	1	Valve, Manual	6 in.	Vacuum Research Co. Model VG-6N5	10464550	
A3325	1	Valve, Manual	1/2 in., Shut-Off	Vacuum Electronics Engr. Co. Model L62P	10464551	
A3326	1	Valve, Manual	1/2 in., Shut-Off	Vacuum Electronics Engr. Co. Model L62P	10464551	
A3327	1	Valve, Manual	1/2 in., Shut-Off	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3328	1	Valve, Manual	1/2 in., Shut-Off	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3329	1	Valve, Manual	1/2 in., Shut-Off	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3330	1	Valve, Manual	2 in., Fill	The Annin Co. Model 1710	10464404	

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3331	1	Valve, Manual	2 in., Fill	The Annin Co. Model 1710	10464404	
A3332	1	Valve, Manual	2 in., Fill	The Annin Co. Model 1710	10464404	
A3333	1	Valve, Manual	2 in., Fill	The Annin Co. Model 1710	10464404	
A3334	1	Valve, Manual	1/2 in., Vent	Vacuum-Electronics Engr. Co. Model L62P	10464551	
A3335	1	Valve, Manual	1/2 in., Drain	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3336	1	Valve, Manual	1/2 in., Shut-Off	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3337	1	Valve, Manual	1/2 in., Shut-Off	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3338	1	Regulator, Pneumatic Flow Control	25 psig Actuator Pressure, 3-15 psig Signal Pressure, 3 in., N.C.	The Annin Co. Model 1660	10464418	50A11
A3339						
A3340	1	Valve, Manual	1/2 in., Shut-Off	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3341	1	Valve, Manual	1/2 in., Vent	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3342	1	Regulator, Pneumatic Flow Control	25 psig Actuator Pressure, 3-15 psig Signal Pressure, 2 in., N.C.	The Annin Co. Model 1760	10464417	50A11

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3343	1	Valve, Manual	1/2 in., Vent	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3344	1	Valve, Solenoid	2 way, 2 position N.C.	Marotta Valve Corp. Model MV-182C	10464421	57A3A1
A3345	1	Regulator	Downstream Pressure, 1/2 in., 50 to 2 psig	Fisher Governor Co. Model 95-L	10464420	
A3346	1	Valve, Manual	1/4 in., Vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3347	1	Valve, Manual	1/4 in., Vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3348	1	Valve, Check	Cracking Pressure 2 psig, 1/2 in.	William Powell Co. Model 70-2341-KD	10464553	
A3349	1	Valve, Check	Cracking Pressure 0.05 psig, 2 in.	Chapman Valve Mfg. Co. Model PB-117948	10464554	
A3350	1	Valve, Manual	1/4 in., Vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3351	1	Valve, Manual	1/4 in.	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3352	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3353	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3354	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3355						
A3356	1	Valve, Manual	1/4 in., Vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3357	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3358	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3359	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3360	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3361	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3362	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3363	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3364	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3365	1	Valve, Check	Cracking Pressure 1 psig, 8 in.	Chapman Valve Mfg. Co. Model PB-117946	10464555	
A3366	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3367	1	Valve, Manual	1/4 in., Vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3368	1	Valve, Manual	Vent			
A3369	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3370	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3371	1	Valve, Manual	1/4 in., Vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3372	1	Valve, Manual	1/4 in.	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3373	1	Valve, Manual	1/4 in., Vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3374	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3375	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3376	1	Valve, Check	Cracking Pressure 0.2 psig, 10 in.	Chapman Valve Mfg. Co. Model PB-117408	10464556	
A3377	1	Valve, Check	8 in.	Chapman Valve Mfg. Co. Model PB-117946	10464555	
A3378	1	Valve, Check	2 in.	Chapman Valve Mfg. Co. Model PB-117948	10464554	

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3379	1	Valve, Manual	6 in., Shut-Off	Pacific Valves, Inc. Model G-710YJ-10K-WE	10464424	
A3380	1	Valve, Manual	6 in., Shut-Off	Vacuum Research Co. Model VG-6N5	10464550	
A3381	1	Valve, Manual	1/4 in., Vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3382	1	Valve, Check	Cracking Pressure 1 psig, 3 in.	Chapman Valve Mfg. Co. Model PB-117947	10464563	
A3383	1	Valve, Check	Cracking Pressure 1 psig, 1 in.	William Powell Co. Model 70-2341	10464564	
A3384	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3385	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3386	1	Valve, Solenoid	3 way, 2 position, N.C.	Marotta Valve Corp. Model MV-74TB	10464413	50A14
A3387	1	Valve, Solenoid	3 way, 2 position, N.C.	Marotta Valve Corp. Model MV-74TB	10464413	50A12
A3388	1	Valve, Solenoid	3 way, 2 position, N.C.	Marotta Valve Corp. Model MV-74TB	10464413	50A10
A3389	1	Valve, Solenoid	3 way, 2 position, N.O.	Marotta Valve Corp. Model MV-74TB	10464413	50A30
A3390	1	Valve, Solenoid	3 way, 2 position, N.C.	Marotta Valve Corp. Model MV-74TB	10464413	50A31

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3415	1	Valve, Manual	3 way, 2 position, 1/4 in., Shut-Off		10466188	
A3416	1	Valve, Manual	1/4 in., Vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3417	1	Valve, Manual	1/2 in., Drain	Hills Mc Canna Co. Model S-303-S6-T	10464567	
A3418	1	Valve, Manual	1/2 in., Drain	Hills Mc Canna Co. Model S-303-S6-T	10464567	
A3419 through A3501 are not functionally applicable to this system.						
A3502	1	Transducer, Differential Pressure	Liquid Level, 0-1 psid Nominal Range		10465305	50MT-2
A3503						
A3504	1	Gage, Liquid Level	125,000 Gallon-Normal 0-130,000 Range	Barton Model 199 Δ P Unit Model 200 Indicator	10466009	
A3505						
A3506	1	Gage, Pressure, Compound	30 in. Hg Vacuum to 60 psig Range		10466007	
A3507	1	Transducer, Pressure	0-50 psig Range	Fairchild Controls Corp. Model 990550-2	10465306	50MT-3
A3508						

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3509	1	Sensor, Liquid Level	10-40 psig for 100 to 0% LH_2 Level		10462814	50A35
A3510						
A3511						
A3512						
A3513	1	Controller, Pneumatic Pressure	10 to 40 psig Input, 15 to 3 psig Output	Bristol Series 624	10466004	
A3514	1	Controller, Pneumatic Pressure	13 to 15 psig Input, 15 to 3 psig Output	Bristol Series 624	10466017	
A3515	1	Controller, Pneumatic Pressure	100 to 0% LH_2 Level, 2 to 0 in. H_2O Input, 3 to 15 psig Output	Barton Model 274 Transmitter Model 199 Δ P Unit	10466010	
A3516 through A3531 are not functionally applicable to this system.						
A3532	1	Gage, Pressure	0-100 psig Range		10466006	
A3533	1	Transducer, Pressure	0-100 psig Range	Fairchild Controls Inc. Model 990550-2	10465306	50MT-2
A3534						
A3535	1	Switch, Pressure	Actuates at 2 psig Decreasing Pressure		10466005-1	50PS-1-1

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3391	1	Valve, Solenoid	3 way, 2 position, N.O.	Marotta Valve Corp. Model MV-74TB	10464413	50A27
A3392	1	Valve, Solenoid	3 way, 2 position, N.C.	Marotta Valve Corp. Model MV-74TB	10464413	50A28
A3393	1	Valve, Solenoid	3 way, 2 position, N.O.	Marotta Valve Corp. Model MV-74TB	10464413	50A33
A3394	1	Valve, Solenoid	3 way, 2 position, N.C.	Marotta Valve Corp. Model MV-74TB	10464413	50A34
A3395	1	Valve, Solenoid	3 way, 2 position, N.O.	Marotta Valve Corp. Model MV-74TB	10464413	50A21
A3396	1	Valve, Solenoid	3 way, 2 position, N.C.	Marotta Valve Corp. Model MV-74TB	10464413	50A22
A3397	1	Valve, Solenoid	3 way, 2 position, N.O.	Marotta Valve Corp. Model MV-74TB	10464413	50A24
A3398	1	Valve, Solenoid	3 way, 2 position, N.O.	Marotta Valve Corp. Model MV-74TB	10464413	50A25
A3399	1	Valve, Manual	1/4 in.	Robbins Aviation, Inc. Model SSKG250-4T	1064559	
A3400						
A3401	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3402	1	Valve, Check	Cracking Pressure 0.1 psig, 1/2 in.	Circle Seal Products, Inc. Model 119T-4PP	10464566	

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3403	1	Valve, Manual	1/4 in., Vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3404	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3405	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3406	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3407	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3408	1	Valve, Manual	1/4 in., Vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3409	1	Valve, Manual	1/4 in.	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3410	1	Valve, Manual	1/4 in., Vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3411	1	Valve, Check	Cracking Pressure 25 psig, 3/4 in.	Circle Seal Products Co., Inc. Model 859T-12BB	10464565	
A3412	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3413	1	Valve, Manual	1/4 in., Shut-Off	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3414	1	Limiter, Differential Pressure	Set Pressure 1 1/2 psid		10466187	

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3536	1	Switch, Pressure	Actuates at 8 psig Decreasing Pressure		10466005-2	50PS-1-2
A3537	1	Switch, Pressure	Actuates at 30 psig Increasing Pressure		10466005-3	50PS-1-3
A3538	1	Switch, Pressure	Actuates at 55 psig Increasing Pressure		10466005-4	50PS-1-4
A3539	1	Switch, Pressure	Actuates at 60 psig Increasing Pressure		10466005-5	50PS-1-5
A3540	1	Switch, Pressure	Actuates at 15 psig Increasing Pressure		10466024	50A42
A3541						
A3542	1	Transducer, Pressure	0 to 20 psia Range	Fairchild Controls, Inc. Model 990550-2	10465306	57A3A2-MT1
A3543						
A3544	1	Controller, Pneumatic Pressure	0 to 100 psig Input, 15 to 3 psig Output	Bristol Series 624	10466001	
A3545						
A3546						
A3547	1	Transducer	0 to 20 psia Range	Fairchild Controls, Inc. Model 990550-2	10465306	50PT-5

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3548						
A3549	1	Gage, Pressure	0-30 psig Range		10466026	
A3550	1	Gage, Pressure	2 psig-Normal Reading, 0-60 psig Range		10466027	
A3551	1	Controller, Pneumatic Pressure	Steady State, 0-4 psig Input, 3 to 15 psig Output	Bristol Series 624	10466003	
A3552	1	Snubber	Set at 10 psig	Sprague Eng. Corp. Model S-214-10	10466014	
A3553						
A3554	1	Controller, Pressure	0-15 psia Input, 3 to 15 psig Output	Bristol Series 624	10466002	
A3555 through A3569 are not functionally applicable to this system.						
A3570						
A3571	1	Indicator, Temperature	0-150 psia Range, -430°F to -403°F		10466008	50T1-1
A3572	1	Transducer, Temperature	Pressure Operated, 0 to 150 psia, -430°F to -403°F	Fairchild Controls, Inc. Model 990550-2	10465306	57A3A2-MT2
A3573						

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3574	1	Probe, Temperature			10466016	50TE1
A3575	1	Switch, Temperature	Pressure Operated, Actuates @ 100 psig Incr. Press. (Equiv. to -406°F)		10466025-1	50TS-1
A3576						
A3577						
A3578	1	Transducer, Temperature	Pressure Operated, 0 to 150 psia -430°F to -403°F	Fairchild Controls, Inc. Model 990550-2	10465306	57A3A2-MT2
A3579						
A3580	1	Probe, Temperature			10466016	50TE2
A3581	1	Switch, Temperature	Pressure Operated, Actuates @ 100 psig Decr. Press. (Equiv. to -406°F)		10466025-2	57A3A2S1
A3582	1	Indicator, Temperature	Pressure Operated, 0-50 psia Range, -430°F to -403°F		10466008	
A3583	1	Probe, Temperature			10466016	50TE4
A3584	1	Indicator, Temperature	Pressure Operated, 0-150 psia Range, -430°F to -403°F		10466008	
A3585	1	Probe, Temperature			10466023	50TE5

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3586	1	Indicator, Temperature	Pressure Operated, 0 to 150 psia Range, -430°F to -403°F		10466008	
A3587	1	Probe, Temperature			10462956	50A37
A3588	1	Switch, Pressure	25 psig			
A3589 through A3600 are not functionally applicable to this system.						
A3601	1	Orifice	0.228 in. Diameter, 20 SCFM Flow Rate		10464423-1	
A3602	1	Orifice	0.052 in. Diameter, 1 SCFM Flow Rate		10464423-2	
A3603	1	Orifice	0.182 in. Diameter, 20 SCFM Flow Rate		10464423-3	
A3604	1	Orifice	0.116 in. Diameter, 8 SCFM Flow Rate		10464423-4	
A3605	1	Orifice	0.116 in. Diameter, 5 SCFM Flow Rate		10464423-4	
A3606	1	Orifice	0.228 in. Diameter, 20 SCFM Flow Rate		10464423-1	
A3607	1	Orifice	0.037 in. Diameter, 0.5 SCFM Flow Rate		10464423-5	
A3608	1	Orifice	0.037 in. Diameter, 0.5 SCFM Flow Rate		10464423-5	

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3609	1	Orifice	0.037 in. Diameter, 0.5 SCFM Flow Rate		10464423-5	
A3610	1	Orifice	0.0156 in. Diameter, 0.1 SCFM Flow Rate		1046118	
A3611 through A3619 are not functionally applicable to this system.						
A3620	1	Analyzer, Oxygen	0-25%, Portable		10466015	
A3621						
A3622	1	Transducer, Vacuum			10466012	50VE1
A3623	1	Transducer, Vacuum			10466012	50VE2
A3624	1	Transducer, Vacuum			10466012	50VE3
A3625 through A3629 are not functionally applicable to this system.						
A3630	1	Disc, Burst	2 in., Rupture at 115-120 psig	Black, Sivalls, & Bryson Inc. Assembly 7, Series 150	10464422	
A3631	1	Disc, Burst	2 in., Rupture at 115-120 psig	Black, Sivalls, & Bryson Inc. Assembly 7, Series 150	10464422	
A3632	1	Disc, Burst	Rupture at 5 psig	Air Products & Chemicals, Inc.		

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3633 through A3639 are not functionally applicable to this system.						
A3640	1	Valve, Relief	Relieves at 100 psig	Manning, Maxwell, & Moore, Inc.	10464412	
A3641	1	Valve, Relief	Relieves at 20 psid	Manning, Maxwell, & Moore, Inc.	10464415	
A3642	1	Valve, Relief	Relieves at 100 psig	Manning, Maxwell, & Moore, Inc.	10464414	
A3643	1	Valve, Relief	Relieves at 100 psig	Manning, Maxwell, & Moore, Inc.	10464414	
A3644	1	Valve, Relief	Relieves at 100 psig	Manning, Maxwell, & Moore, Inc.	10464414	
A3645	1	Valve, Relief	Relieves at 5 psig	Manning, Maxwell, & Moore, Inc.	10464419	
A3646	1	Valve, Relief	Relieves at 100 psig	Manning, Maxwell, & Moore, Inc.	10464414	
A3647	1	Valve, Relief	Relieves at 100 psig	Manning, Maxwell, & Moore, Inc.	10464414	
A3648 through A3699 are not functionally applicable to this system.						
A3700	1	Gage, Pressure	3500 psig-Normal Reading, 0 to 10,000 psig Range	U. S. Gauge Company	10437648	
A3701	1	Gage, Pressure	750 psig-Normal Reading, 0 to 1500 psi Range	U. S. Gauge Company	10437688	

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3702	1	Gage, Pressure	120 psig-Normal Reading, 0 to 300 psi Range	U. S. Gauge Company	10437687	
A3703	1	Gage, Pressure	25 psig-Normal Reading, 0 to 60 psi Range	U. S. Gauge Company	10437686	
A3704	1	Regulator, Pneumatic	Downstream Pressure, 3500 psig Inlet to 750 psig Outlet	Grove Valve & Regulator Co. Model No. 94X	10437651	
A3705	1	Regulator, Pneumatic	Downstream Pressure, 750 psig Inlet to 120 psi Outlet	Grove Valve & Regulator Co. Model No. 94X	10437651	
A3706	1	Regulator, Pneumatic	Downstream Pressure, 120 psig Inlet, to 25 psi Outlet	Moore Products Co. Model 42H50	10437679	
A3707	1	Filter, Pneumatic	10 Micron	Permanent Filter Corp. PN 10813	10437650	
A3708	1	Valve, Relief	Cracks at 900 ± 50 psig, Reseats at 750 psig min.	Republic Manufacturing Co. PN 625B-9-6	10437652	
A3709	1	Valve, Relief	Cracks at 120 psig, Reseats at 100 psig min.	Republic Manufacturing Co. PN 625B-3-6	10437680	
A3710	1	Valve, Relief	Cracks at 35 ± 5 psig, Reseats at 25 psig min.	Republic Manufacturing Co. PN 625-2-8	10437681	
A3711	1	Switch, Pressure	Actuates at 21.5 ±0.5 psig Rising. Deactuates within 1.5 psig of Actuation Press.	Southwestern Industries Inc. PN PS-3700A-4	10437682	50A42
A3712	1	Valve, Manual	5/16 in.	Robbins Aviation PN SSNA-375A-6T	10437684	
A3713	1	Valve, Manual	5/16 in.	Robbins Aviation PN SSNA-375A-6T	10437684	

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3714	1	Valve, Manual	5/16 in.	Robbins Aviation PN SSNA-375A-6T	10437684	
A3715	1	Valve, Manual	5/16 in.	Robbins Aviation PN SSNA-375A-6T	10437684	
A3716	1	Valve, Manual	1/4 in., Vent	Futurecraft Corp. PN 30205	10437647	
A3717	1	Valve, Manual	1/4 in., Vent	Futurecraft Corp. PN 30205	10437647	
A3718	1	Valve, Manual	1/4 in., Vent	Futurecraft Corp. PN 30205	10437647	
A3719	1	Valve, Manual	1/4 in., Vent	Futurecraft Corp. PN 30205	10437647	
A3720	1	Valve, Manual	5/16 in.	Robbins Aviation PN SSNA-375A-6T	10437684	
A3721	1	Valve, Manual	1/4 in., Vent	Futurecraft Corp. PN 30205	10437647	
A3722	1	Valve, Manual	1/4 in., Vent	Futurecraft Corp. PN 30205	10437647	
A3723	1	Valve, Manual	1/4 in., Vent	Futurecraft Corp. PN 30205	10437647	
A3724	1	Valve, Manual	1/4 in., Vent	Futurecraft Corp. PN 30205	10437647	
A3725	1	Switch, Pressure	Actuates at 600 ± 20 psig, Deactuation at 50 psig Less than Actuation Pressure	Southwestern Industries PN-PS-5100A	10437683	50A43

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3726 through A3749 are not functionally applicable to this system.						
A3750	1	Pump, Vacuum		F. J. Stokes Model 412-10		
A3751	1	Pump, Vacuum	Subcooler 8 in. bore x 5 in. stroke	Air Products & Chemicals Inc.	10462950	
A3752	1	Subcooler	Supercool LH_2 from -423°F to -426°F		10462950	
A3753	1	Storage Tank	Capacity-125,000 Gallons, LH_2	Air Products & Chemicals Inc.		
A3754	1	Vaporizer				
A3755	3	Valve, Relief	Cracks at 2.5 to 6 psig	James Pond and Clark P/N D559T-2M-4		
A3756 through A3770 are not functionally applicable to this system.						
A3771	1	Valve, Manual	5/16 in.			
A3772 through A3899 are not functionally applicable to this system.						
A3900	1	Transducer, Pressure	1/4 in., 0 to 100 psia Range	Douglas Aircraft Co. PN 7870467-511		446PT8
A3901 through A3904 are not functionally applicable to this system.						

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3905	1	Filter	4 in., 125-micron	Capitol Westward Inc. PN 25111		
A3906	1	Valve, Solenoid	4 way, 2 position 750 psig	Southwestern Valve Corp. PN 804934-1-2		446NS11
A3907 through A3909 are not functionally applicable to this system.						
A3910	1	Valve, Pneumatic	2 in., 3 position, N.C., Replenish	Pacific Valves Inc. PN 13512-EO		
A3911	1	Valve, Pneumatic	4 in., 2 position, N.C. Main Fill	Pacific Valves Inc. PN 13396-EO		
A3912	1	Valve, Pneumatic	2 in., N.C., Line Drain	Pacific Valves Inc. PN 13395-EO		
A3913 through A3915 are not functionally applicable to this system.						
A3916	1	Transducer, Pressure	1/4 in., 0 to 100 psia	Bourns PN 2004201907		446PT9
A3917	1	Valve, Pneumatic	1 1/2 in., N.C., Supply	Douglas Aircraft Co. PN 7866052-501		446NS14
A3918 through A3921 are not functionally applicable to this system.						
A3922	1	Valve, Solenoid	4 way, 2 position, 750 psig	Southwestern Valve Corp. PN 804934-1-2		446NS43
A3923	1	Valve, Solenoid	4 way, 2 position, 750 psig	Southwestern Valve Corp. PN 804934-1-2		446NS11

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3924						
A3925	1	Valve, Solenoid	4 way, 2 position, 750 psig	Southwestern Valve Corp. PN 804934-1-2		446NS12
A3926 through A3930 are not functionally applicable to this system.						
A3931	1	Valve, Solenoid	4 way, 2 position, 750 psig	Southwestern Valve Corp. PN 804934-1-2		446NS14
A3932	1	Valve, Relief	Cracks 92 ± 2 psig Reseats 84 ± 2 psig, 1 in.	W.R. Ladewig Co. PN L-1180C-757-1		
A3933						
A3934						
A3935						
A3936	1	Coupling Half				
A3937	1	Coupling Half				
A3938	1	Motor	15 h.p., Vacuum Pump	U.S. Electrical Motors, Inc. Type J	10462945	50B1
A3939	1	Motor	15 h.p.	U.S. Electrical Motors, Inc. Type J	10462945	50B2

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
A3940	1	Coupling Half				
A3941	1	Coupling Half				
A3942	1	Coupling Half				
A3943	1	Coupling Half				
A3944	1	Orifice		Del Mfg. Co. DR4-0.5		
A3945	1	Switch, Pressure		Douglas Aircraft Co. PN 1A22553		446PJ2
A3946	1	Coupling Half				
A3947	1	Coupling Half				
A3948	1	Coupling Half				
A3949	1	Transducer, Pressure Differential		Douglas Aircraft Co. PN 1A19707-503		446PT65
A3950 through E99 are not functionally applicable to this system.						
E100	1	Nozzle, Quick Disconnect	LH_2	Douglas Aircraft Co. PN 1A84413	75M04588	

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
E101						
E102	1	Tank Assembly	28,000 gal.	Douglas Aircraft Co.		
E103						
E104						
E105	1	Nipple, Disconnect Assembly		Douglas Aircraft Co. PN 1A38252-1		
E106-1						
E106-2						
E107	1	Probe, Liquid Level	LH_2 Sensor	Minneapolis-Honeywell PN FQ360B-1		409A1
E108 through E112 are not functionally applicable to this system.						
E113	1	Valve, Butterfly	3 in., N.C., Fill & Drain	B.H. Hadley Inc. PN 11084-13		407A16
E114	1	Valve, Vent and Relief	Vents @ 455 ± 25 psia Relieves @ 44 psia max.	Calmec Mfg. Corp. PN 231-501		
E115	1	Valve, Vent and Relief	Vents @ 455 ± 25 psia Relieves @ 44 psia max.	Calmec Mfg. Corp. PN 231-501		

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
E116 through E208 are not functionally applicable to this system.						
E209	1	Valve, Solenoid	3 way, 2 position, N.C.	Marotta Valve Corp. PN 223544-1		410L1
E210	1	Valve, Solenoid	3 way, 2 position, N.C.	Marotta Valve Corp. PN 223544-1		410L2
E211	1	Valve, Solenoid	3 way, 2 position, N.C.	Marotta Valve Corp. PN 223544-1		410L3
E212 through E249 are not functionally applicable to this system.						
E250	1	Coupling Half		On-Mark Couplings, Inc. PN 2-1223-12		
E251	1	Valve, Check	Cracking Pressure 1 to 3 psig	Wm. Lanagan Co. PN 90054		
E252	1	Union, Orifice	0.209 in. dia. 1-3/8 x 2 in.	Douglas Aircraft Co. PN 4884302-523		
E253	1	Union, Orifice	0.027 in. dia. 1-3/8 x 2 in.	Douglas Aircraft Co. PN 4884302-521		
E254	1	Valve, Electropneumatic	450 psig	Wallace O. Leonard Co. PN 194050-2		407L1
E255	1	Valve, Electropneumatic	450 psig	Wallace O. Leonard Co. PN 194050-2		407L2
E256	1	Union, Orifice	0.397 in. dia. 1-3/8 x 2 in.	Douglas Aircraft Co. PN 4884302-525		

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
E257	1	Valve, Solenoid	2 way, 2 position, N.C.	Marotta Valve Corp. PN 220683		407L11
E258	1	Valve, Check	Cracks @ 2 to 8 psig	W.M. Lanagan Co. PN 90048		
E259	1	Union, Orifice	0.068 in. dia.	Douglas Aircraft Co. PN S 4851838C4-068		
E260 through E274 are not functionally applicable to this system.						
E275	1	Switch, Differential Pressure	Actuates @ 4 ± 1 psid, Deactuates @ 2 ± 1 psid	Frebank Co. PN 4566-2		410S2
E276	1	Switch, Pressure	Actuates @ 37.25 ± 0.75 psia, Deactuates @ 35.75 ± 0.75 psia	Frebank Co. PN 8015-1		410S3
E277	1	Switch, Pressure	Actuates @ 31.5 ± 0.5 psia, Deactuates @ 30.5 ± 0.5 psia	Frebank Co. PN 4640-1		410S1
E278	1	Switch, Pressure	Actuates @ 34.5 ± 0.5 psia, Deactuates @ 33.5 ± 0.5 psia	Frebank Co. PN 8015-3		410S5
E279	1	Switch, Pressure	Actuates @ 29.5 ± 0.5 psia, Deactuates @ 27.5 ± 0.5 psia	Frebank Co. PN 8015-10		410S1
E280 through E320 are not functionally applicable to this system.						
E321	1	Valve, Solenoid	3 way, 2 position	Marotta Valve Corp PN 223544-1		407L20
E322	1	Valve, Solenoid	3 way, 2 position	Marotta Valve Corp. PN 223544-1		407L21

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
E323 and subsequent finding numbers are not functionally applicable to this system.						

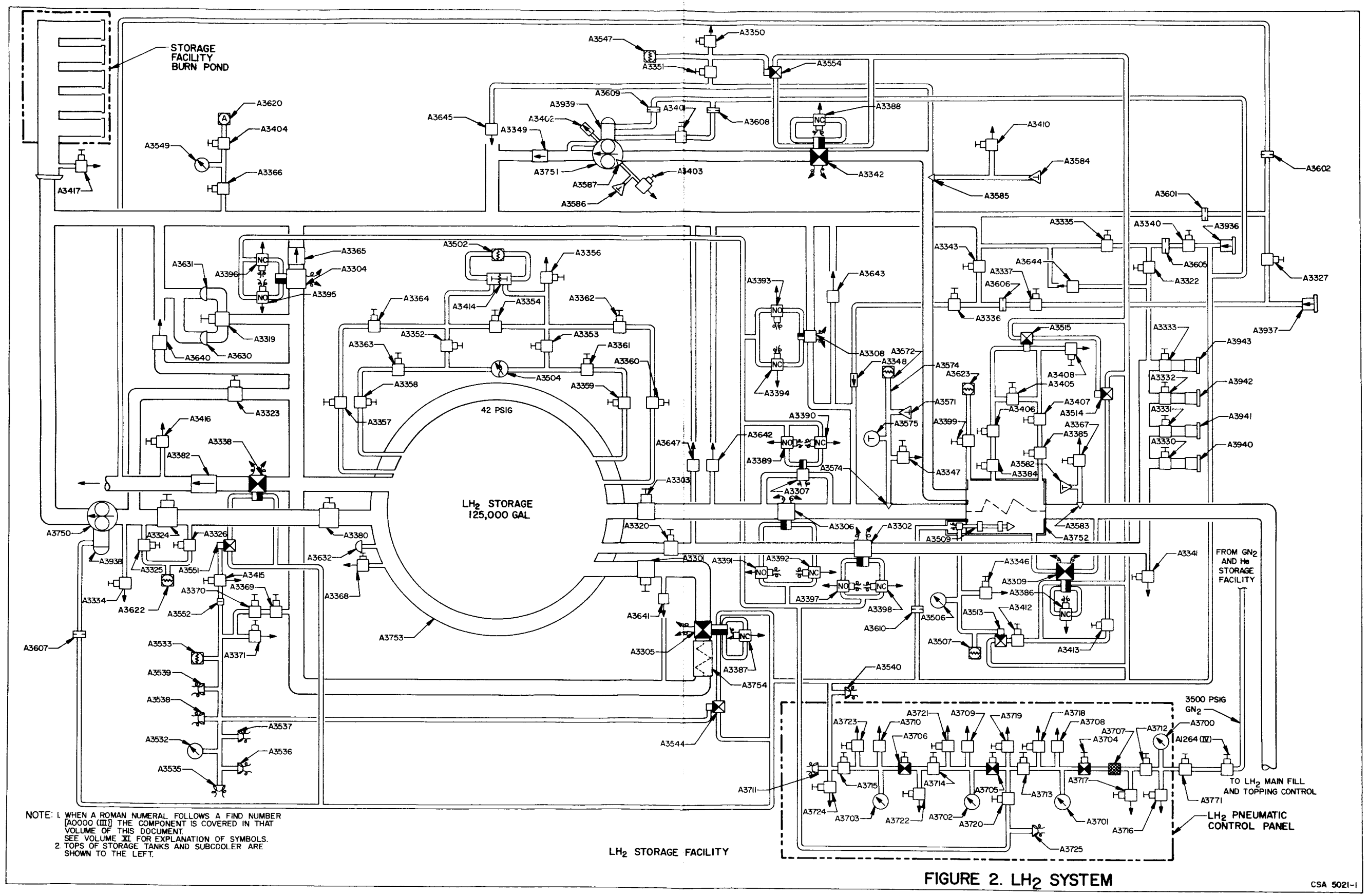

FIGURE 2. LH_2 SYSTEM

CSA 5021-1

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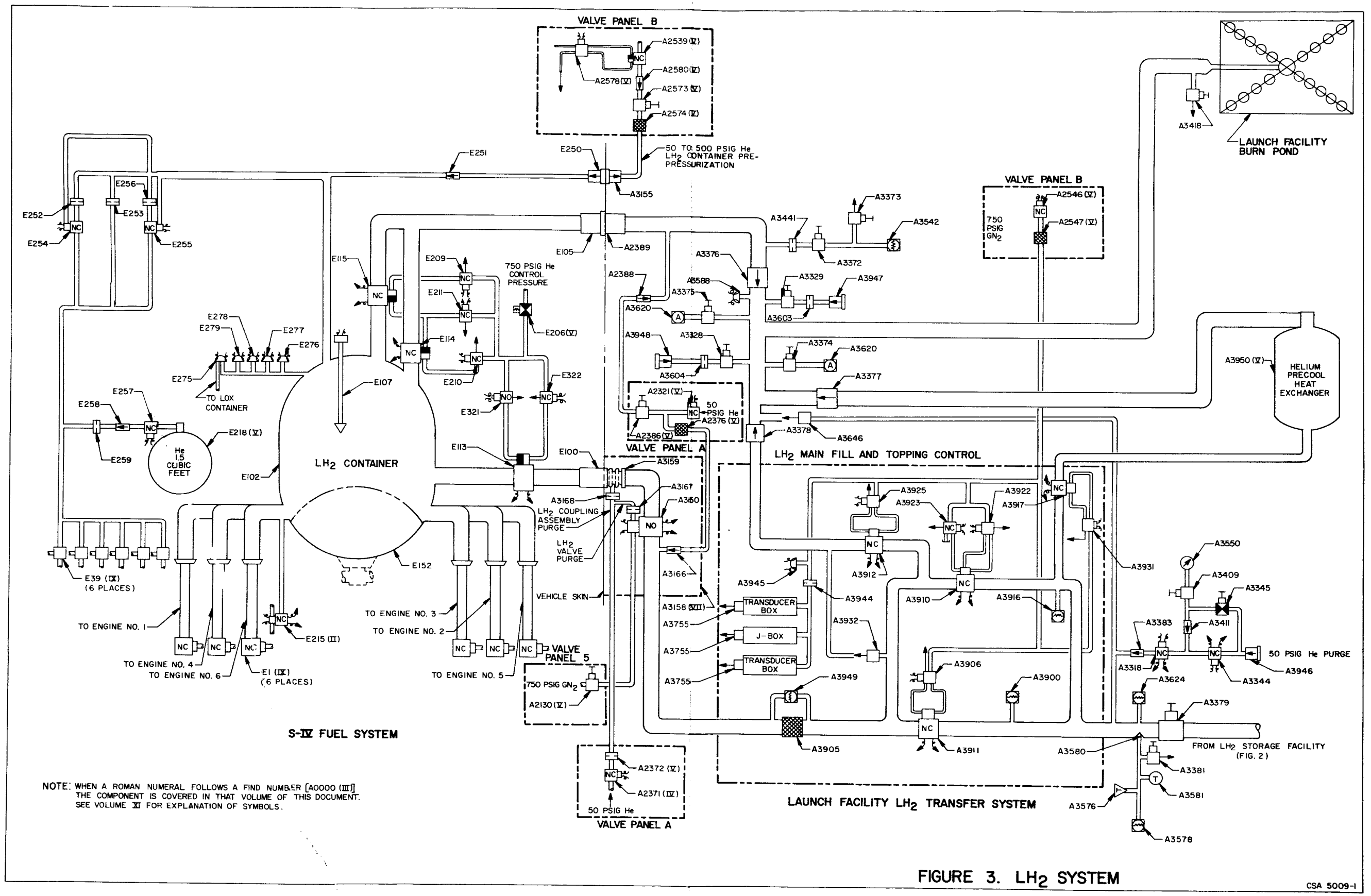

NOTE: WHEN A ROMAN NUMERAL FOLLOWS A FIND NUMBER [A0000 (III)] THE COMPONENT IS COVERED IN THAT VOLUME OF THIS DOCUMENT. SEE VOLUME II FOR EXPLANATION OF SYMBOLS.

FIGURE 3. LH_2 SYSTEM

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